U.S. DEPARTMENT OF THE INTERIOR

BUREAU OF RECLAMATION

NAVAJO GALLUP WATER SUPPLY PROJECT, NEW MEXICO

BIDDING REQUIREMENTS
AND
CONTRACT DOCUMENTS

for the construction of the

CUTTER LATERAL REACH 21 WATER TREATMENT PLANT

60% Submittal

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CH2M HILL

Denver, CO

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Project No. 682853

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SECTION 01 88 15
ANCHORAGE AND BRACING

PART 1 GENERAL

1.01 SUMMARY

A. This section covers requirements for anchorage and bracing of equipment, distribution systems, and other nonstructural components required in accordance with the ICC 2015 International Building Code (IBC), for seismic, wind, gravity, soil, and operational loads.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Institute of Steel Construction (AISC) 360, Specification for Structural Steel Buildings.
2. American Society of Civil Engineers (ASCE): ASCE 7, Minimum Design Loads for Buildings and Other Structures.
3. International Code Council (ICC): International Building Code (IBC).
4. **[A: National Fire Protection Association (NFPA): 13, Standard for the Installation of Sprinkler Systems.]**
5. **[B: State of _____.**]

1.03 DEFINITIONS

A. Authority Having Jurisdiction (AHJ): Permitting building agency; may be a federal, state, local, or other regional department, or individual including building official, fire chief, fire marshal, chief of a fire prevention bureau, labor department, or health department, electrical inspector; or others having statutory authority. AHJ may be Owner when authorized to be self-permitting by governmental permitting agency or when no governmental agency has authority.

B. Designated Seismic System: Architectural, electrical, and mechanical system or their components for which component importance factor is greater than 1.0.

1.04 DESIGN AND PERFORMANCE REQUIREMENTS

A. General:

1. Anchorage and bracing systems shall be designed by a qualified professional engineer registered in the State of New Mexico.

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2. Design anchorage and bracing of architectural, mechanical, and electrical components and systems in accordance with this section, unless a design is specifically provided within Contract Documents or where exempted hereinafter.
3. Design attachments, braces, and anchors for equipment, components, and distribution systems to structure for gravity, seismic, wind, and operational loading.
4. Anchor and brace piping and ductwork, whether exempt or not exempt for this section, so that lateral or vertical displacement does not result in damage or failure to essential architectural, mechanical, or electrical equipment.
5. Architectural Components: Includes, but are not limited to, nonstructural walls and elements, partitions, cladding and veneer, access flooring, signs, cabinets, suspended ceilings, and glass in glazed curtain walls and partitions.
6. Provide supplementary framing where required to transfer anchorage and bracing loads to structure.
7. Adjust equipment pad sizes or provide additional anchorage confinement reinforcing to provide required anchorage capacities.
8. Design anchorage and bracing for:
    a. Equipment and components that weigh more than 400 pounds and have center of mass located 4 feet or less above adjacent finished floor.
    b. Equipment weighing more than 75 pounds that has center of mass located more than 4 feet above adjacent finished floor.
    c. Distribution systems that weigh more than 5 pounds per foot that have center of mass located more than 4 feet above adjacent finished floor.
9. For components exempted from design requirements of this section, provide bolted, welded, or otherwise positively fastened attachments to supporting structure.

B. Design Loads:

1. Gravity: Design anchorage and bracing for self weight and superimposed loads on components and equipment.
2. Wind: Design anchorage and bracing for wind criteria provided on General Structural Notes on Drawings for exposed architectural components and exterior and wind-exposed mechanical and electrical equipment. Alternately, manufacturer certification may be provided for components such as roofing and flashing to verify attachments meet Project-specific design criteria.
3. Operational:
    a. For loading supplied by equipment manufacturer for IBC required load cases.

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b. Loads may include equipment vibration, torque, thermal effects, effects of internal contents (weight and sloshing), water hammer, and other load-inducing conditions.
c. Locate braces to minimize vibration to or movement of structure.
d. For vibrating loads, use anchors meeting requirements of Section 05 50 00, Metal Fabrications for anchors with designated capacities for vibratory loading per manufacturer's ICC-ES report.

4. Hydraulic: Design of anchorage for submerged gates and other mechanical equipment shall include hydrostatic and hydrodynamic loads determined in accordance with Section 15.7 of ASCE 7-10.
5. Seismic:
   a. In accordance with 2015 IBC, Section 1613, and Chapter 13 of ASCE 7.
   b. Design anchorage and bracing for design criteria listed on General Structural Notes on Drawings.
   c. Design anchorages for parts or elements of architectural, mechanical, and electrical systems in accordance with provisions of IBC and following Site-specific seismic criteria, unless noted otherwise on Drawings:
      1) Site-Specific Spectral Response Coefficients:
         a) Short Period Mapped Maximum Considered Earthquake Acceleration, 5 Percent Damped: SS equals 0.146 g.
         b) 1 Period Mapped Maximum Considered Earthquake Acceleration, 5 Percent Damped: S1 equals 0.057g.
      2) Short Period Design Spectral Response Acceleration, 5 Percent Damped: SDS equals 0.156g.
         a) 1 Second Period Design Spectral Response Acceleration, 5 Percent Damped: SD1 equals 0.091g.
      3) Site Class: D.
      4) Seismic Design Category (SDC): C, unless noted otherwise. Same as supporting structure's SDC, as shown on Drawings.
      5) Risk Category: IV, unless noted otherwise. Anchorage and bracing Risk Category shall be same as that for supporting structure as shown on Drawings.
   d. Design forces for anchors in concrete or masonry shall be in accordance with ASCE 7, Section 13.4.2 as applicable for Project Seismic Design Category.

C. Seismic Design Requirements:

1. Nonstructural Components: Design as nonbuilding structures for components with weights greater than or equal to 25 percent of effective seismic weight of overall structure.

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2. Analyze local region of body of nonstructural component for load transfer of anchorage attachment if component Ip = 1.5.
3. The following are exempt from requirements for provision of seismic anchorages and bracing, in addition to those items specifically exempted in ASCE 7, Part 13.5 for architectural components and Part 13.6 for electrical and mechanical equipment:
    a. Furniture, except storage cabinets and bookshelves over 6 feet tall.
    b. Temporary or movable equipment.
4. Fire protection sprinkler systems designed and constructed in accordance with NFPA 13 shall be considered to meet requirements of Chapter 13 of ASCE 7.
5. Provide support drawings and calculations for electrical distribution components if any of the following conditions apply:
    a. Ip is equal to 1.5 and conduit diameter is greater than 2.5-inch trade size.
    b. Ip is equal to 1.5 and the total weight of bus duct, cable tray, or conduit supported by trapeze assemblies exceeds 10 pounds per foot.
    c. Supports are cantilevered up from floor.
    d. Supports include bracing to limit deflection and are constructed as rigid welded frames.
    e. Attachments utilize spot welds, plug welds, or minimum size welds as defined by AISC.
6. Other seismic design and detailing information identified in ASCE 7, Chapter 13, is required to be provided for new architectural, mechanical and electrical components, systems, or equipment.

1.05 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
    a. List of architectural, mechanical, and electrical equipment requiring Contractor-designed anchorage and bracing, unless specifically exempted.
    b. Manufacturers' engineered seismic and non-seismic hardware product data.
    c. Attachment assemblies' drawings including seismic attachments; include connection hardware, braces, and anchors or anchor bolts for nonexempt components, equipment, and systems.
    d. Submittal will be rejected if proposed anchorage method would create excessive stress to supporting member. Revise anchorages and strengthen structural support to eliminate overstressed condition.

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B. Informational Submittals:

1. Anchorage and Bracing Calculations: For attachments, braces, and anchorages, include IBC and Project-specific criteria as noted on General Structural Notes on Drawings, in addition to manufacturer's specific criteria used for design; sealed by a civil or structural engineer registered in the State of New Mexico.
2. Manufacturer's hardware installation requirements.

C. Deferred Submittals:

1. Submitted seismic anchorage drawings and calculations are identified as IBC deferred submittals and will be submitted to and must be accepted by AHJ prior to installation of component, equipment, or distribution system.
2. Submit deferred Action Submittals such as Shop Drawings with supporting deferred informational submittals such as calculations no less than 4 weeks in advance of installation of component, equipment or distribution system to be anchored to structure.

1.06 SOURCE QUALITY CONTROL

A. Contractor and supplier responsibilities to accommodate Owner-furnished shop fabrication related special inspections and testing are provided in Project's Statement of Special Inspections on Drawings and Section 01 45 33, Special Inspection, Observation, and Testing.

B. Provide all other specified, regulatory required, or required repair verification inspection and testing that is not listed in Statement of Special Inspections in accordance with Section 01 45 16.13, Contractor Quality Control.

C. Provide Source Quality Control for welding and hot-dip galvanizing of anchors in accordance with Section 05 50 00, Metal Fabrications.

PART 2 PRODUCTS

2.01 GENERAL

A. Design and construct attachments and supports transferring seismic and non-seismic loads to structure of materials and products suitable for application and in accordance with design criteria shown on Drawings and nationally recognized standards.

B. Provide anchor bolts for anchorage of equipment to concrete or masonry in accordance with Section 05 50 00, Metal Fabrications. Provide anchor bolts of the size, minimum embedment, and spacing designated in calculations submitted by Contractor and accepted by Engineer.

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C. Provide post-installed concrete and masonry anchors for anchorage of equipment to concrete or masonry in accordance with Section 05 05 19, Post-Installed Anchors. Provide post-installed anchors of the size, minimum embedment, and spacing designated in calculations submitted by Contractor and accepted by Engineer.

D. Do not use powder-actuated fasteners or sleeve anchors for seismic attachments and anchorage where resistance to tension loads is required. Do not use expansion anchors, other than undercut anchors, for nonvibration isolated mechanical equipment rated over 10 horsepower.

PART 3 EXECUTION

3.01 GENERAL

A. Make attachments, bracing, and anchorage in such a manner that component lateral force is transferred to lateral force resisting system of structure through a complete load path.

B. Design, provide, and install overall seismic anchorage system to provide restraint in all directions, including vertical, for each component or system so anchored.

C. Provide snubbers in each horizontal direction and vertical restraints for components mounted on vibration isolation systems where required to resist overturning.

D. Provide piping anchorage that maintains design flexibility and expansion capabilities at flexible connections and expansion joints.

1. Piping and ductwork suspended more than 12 inches below supporting structure shall be braced for seismic effects to avoid significant bending of hangers and their attachments unless HVAC ducts have a cross-sectional area of less than 6 square feet.

E. Anchor tall and narrow equipment such as motor control centers and telemetry equipment at base and within 12 inches from top of equipment, unless approved otherwise by Engineer.

F. Do not attach architectural, mechanical, or electrical components to more than one element of a building structure at a single restraint location where such elements may respond differently during a seismic event. Do not make such attachments across building expansion and contraction joints.

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3.02 INSTALLATION

A. Do not install components or their anchorages or restraints prior to review and acceptance by Engineer and AHJ.

B. Notify Engineer upon completion of installation of seismic restraints in accordance with Section 01 45 33, Special Inspection, Observation, and Testing.

3.03 FIELD QUALITY ASSURANCE AND QUALITY CONTROL

A. In accordance with Section 05 50 00, Metal Fabrications, and Section 05 05 19, Post-Installed Anchors.

B. Owner-Furnished Quality Assurance, in accordance with IBC Chapter 17 requirements, is provided in Statement of Special Inspections Plan on Drawings. Contractor responsibilities and related information are included in Section 01 45 33, Special Inspection, Observation, and Testing.

C. Provide any other specified, regulatory required, or required repair verification inspection and testing that is not listed in Statement of Special Inspections in accordance with Section 01 45 16.13, Contractor Quality Control.

END OF SECTION

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SECTION 03 01 32
REPAIR OF VERTICAL AND OVERHEAD CONCRETE SURFACES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Concrete Institute (ACI):
   a. 301, Specifications for Structural Concrete.
   b. 506.2, Specification for Shotcrete.
2. ASTM International (ASTM):
   a. A82/A82M, Standard Specification for Steel Wire, Plain, for Concrete Reinforcement.
   b. A185/A185M, Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete.
   c. A615/A615M, Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
   d. A706/A706M, Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement.
   e. C42/C42M, Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete.
   f. C78/C78M, Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading).
   g. C109/C109M, Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50-mm] Cube Specimens).
   h. C157/C157M, Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete.
   i. C348, Standard Test Method for Flexural Strength of Hydraulic-Cement Mortars.
   j. C496/C496M, Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens.
   k. C531, Standard Test Method for Linear Shrinkage and Coefficient of Thermal Expansion of Chemical-Resistant Mortars, Grouts, Monolithic Surfacings, and Polymer Concretes.
   l. C596, Standard Test Method for Drying Shrinkage of Mortar Containing Hydraulic Cement.
   m. C666/C666M, Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing.
   n. C882/C882M, Standard Test Method for Bond Strength of Epoxy-Resin Systems Used with Concrete by Slant Shear.
   o. C1202, Standard Test Method for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration.

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p. C1583/C1583M, Standard Test Method for Tensile Strength of Concrete Surfaces and the Bond Strength or Tensile Strength of Concrete Repair and Overlay Materials by Direct Tension (Pull-off Method).
q. D4258, Standard Practice for Surface Cleaning Concrete for Coating.
r. D4259, Standard Practice for Abrading Concrete.
s. E699, Standard Practice for Evaluation of Agencies Involved in Testing, Quality Assurance, and Evaluating of Building Components.

3. NSF International (NSF): 61, Standard for Drinking Water System Components – Health Effects.

1.02 DEFINITIONS

A. Abrasive Blasting: Surface preparation method that uses compressed air intermixed with an abrasive medium to clean surface of substrate concrete, exposed steel, and steel reinforcement. Compressed air and abrasive medium is projected at high speed through a nozzle directly at the surface. Method is used to remove corrosion by-products, laitance, or other materials that may inhibit bond of repair concrete.

B. Defective Area: As defined in Section 03 30 00, Cast-in-Place Concrete.

C. High-Pressure Water Blasting: Sometimes referred to as hydro-demolition. Uses water that may contain an abrasive medium, projected under high pressure and high velocity. Used for demolition, cutting, partial or full depth removal, cleaning, scarifying, or roughening of concrete surfaces, or removing existing coatings, for preparation of substrate concrete surfaces.

D. Low-Pressure Spray Mortar: Mortar suitable to be applied by low-pressure spraying, and in small areas may be applied by hand troweling.

E. New Concrete: As defined in Section 03 30 00, Cast-in-Place Concrete.

F. Rebound: Shotcrete material, mostly aggregates, that bounce off a surface against which shotcrete was projected.

G. Shotcrete: Mortar pumped through hose and projected at high velocity.

1.03 SUBMITTALS

A. Action Submittals:

1. Product data sheets for each material supplied.

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2. Drawings supplemented by photographs indicating location, size, estimated quantity, and proposed repair mortar for each repair location in existing concrete.
3. Drawings indicating results of sounding for hollow areas including location, size, and estimated quantity of hollow-sounding areas for each repair location.

B. Informational Submittals:

1. Repair Mortar System: Manufacturer's preparation and installation instructions.
2. Mesh manufacturer's installation instructions and allowable load criteria.
3. Written description of equipment proposed for concrete removal and surface preparation.
4. Certificates:
    a. Shotcrete Nozzleman: Current ACI Certification for each proposed nozzleman.
    b. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements, that proposed repair mortar systems are prepackaged, shrinkage compensated, specially designed for use on vertical and overhead surfaces that are exposed to potable water.
    c. Mortar Manufacturer's Certificate of Proper Installation.
    d. Confirmation material is certified to meet requirements of NSF 61.
5. Statements of Qualification:
    a. Repair mortar system applicator.
    b. Repair mortar system manufacturer's representative.
    c. Independent Testing Laboratory.
6. Repair mortar system manufacturer's proposed modified test procedures for ASTM C109/C109M, ASTM C882/C882M, and ASTM C157/C157M test methods.
7. Field and laboratory test reports.

1.04 QUALITY ASSURANCE

A. Qualifications:

1. Repair Mortar System Applicator:
    a. For Repair System A – Shotcrete Mortar, trained and experienced applicator recognized or certified by repair mortar system manufacturer.
    b. For Repair System B – Low-Pressure Spray Mortar, in lieu of recognition or certification, demonstrate application of repair

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mortar manufacturer's system and obtain Certification of Proper Installation, in accordance with Article Manufacturer's Services.

2. Repair Mortar System Manufacturer's Representative: Knowledgeable and experienced on technical data and application requirements for specified products.

B. Independent Testing Laboratory: Meet criteria stated in ASTM E699.

C. Demonstration Mockup for Repair System A – Shotcrete Mortar and Repair System B – Low-Pressure Spray Mortar Repair System:

1. For each noted type of repair mortar system to be used, prepare one demonstration mockup in each vertical and overhead orientation of at least 10 feet by 10 feet with average thickness, and containing reinforcement, representative of area being repaired on Project. Alternatively, a repair area in each vertical and overhead orientation that is representative of areas to be repaired in terms of size, thickness, and reinforcement, may be used for demonstration in lieu of mockups; subject to acceptance by Engineer.
2. Repair Mortar System Manufacturer's Demonstration:
    a. Schedule time for manufacturer's demonstration of repair system proposed for Project.
    b. Prepare mortar to specified consistency for testing and placement.
    c. Cure portions of each type of surface to be repaired using proposed curing procedure and materials, including overhead and vertical applications.
    d. Prepare surface area in advance of demonstration and obtain manufacturer's acceptance of preparation for each type of application.
    e. Demonstrate the following:
        1) Mixing and application equipment capabilities and procedures, including flow of material from nozzle or sprayer.
        2) Nozzle operator and person in charge of low-pressure sprayer, capabilities and ability to follow prescribed application procedures and properly operate equipment and apply surface repair materials.
    f. Compression Strength Test: Make compression test samples from wet mortar during demonstration placement and deliver to independent testing laboratory for testing at 7 days and 28 days.
    g. Tensile Bond Test: Test in situ for tensile bond at 7 days as specified in Paragraph Direct Tension Bond Test.

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D. Where Required by Engineer: Demonstration Mockup for Repair System C – Polymer Modified Repair Mortar System:

1. Prepare one demonstration mockup in each vertical and overhead orientation of average size and thickness, and containing reinforcement, representative of area being repaired on Project. Alternatively, a repair area in each vertical and overhead orientation that is representative of areas to be repaired in terms of size, thickness, and reinforcement, may be used for demonstration in lieu of mockups; subject to acceptance by Engineer.
2. Repair Mortar System Manufacturer's Demonstration:
    a. Schedule time for manufacturer's demonstration of repair system proposed for Project.
    b. Prepare mortar to specified consistency, for testing and placement.
    c. Cure portions of each type of surface to be repaired using proposed curing procedure and materials, including overhead and vertical applications.
    d. Prepare surface area in advance of demonstration and obtain manufacturer's acceptance of preparation for each type of application.
    e. Demonstrate mixing and application procedures.
    f. Compression Strength Test: Make compression test samples from wet mortar during demonstration placement and deliver to independent testing laboratory for testing at 7 days and 28 days.
    g. Tensile Bond Test: Test in situ or take a core of demonstration placement and test for tensile bond at 7 days as specified in Paragraph Direct Tension Bond Test.

E. Pre-repair Conference:

1. Required Meeting Attendees:
    a. Contractor.
    b. Repair Subcontractor.
    c. Technical representative for repair material manufacturer.
    d. Engineer.
2. Schedule and conduct prior to conducting mockups and incorporation of respective products into Project. Notify Engineer of location and time.
3. Agenda shall include, but not limited to:
    a. Review of field conditions. Conduct field observations of Work to be performed.
    b. Based on above observations, repair material manufacturer's technical representative shall confirm material selection and make Project-specific repair method recommendations.
    c. Technical representative for repair material manufacturer shall review proposed surface preparation, material application,

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consolidation, finishing, curing, and protection of repair material from weather conditions.

d. Other specified requirements requiring coordination.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Package repair mortar system products in moisture-resistant bags, pails, or moisture-resistant bulk bags.

B. Deliver, store, and handle repair materials in accordance with manufacturer's printed instructions.

PART 2 PRODUCTS

2.01 REPAIR SYSTEM A – SHOTCRETE MORTAR

A. Mortar Materials:

1. Blend of selected portland cements, microsilica, and specially graded aggregates and fibers applicable for vertical and overhead surfaces.
2. Materials shall not contain asbestos, chlorides, nitrates, added gypsum, added lime, or high aluminum cements.
3. Noncombustible before and after cure.
4. Furnish in factory proportioned unit.
5. Workability from 1/4 inch in depth and greater.

B. Mixed Mortar Properties:

1. Working Time: 5 minutes to 10 minutes.
2. Finishing Time: 10 minutes to 20 minutes.
3. Color: Dark gray.

C. Cured Mortar Properties:

1. Compressive strength for 2-inch cubes in accordance with ASTM C109/C109M, or 3-inch cubes in accordance with manufacturer's modification to ASTM C109/C109M:
   a. 7 Days: 6,000 psi minimum.
   b. 28 Days: 7,000 psi minimum.
2. Flexural Strength (Modulus of Rupture), ASTM C78/C78M or ASTM C348 (Modified) at 28 Days: 1,100 psi minimum.
3. Splitting Tensile Strength, ASTM C496/C496M at 28 Days: 400 psi minimum.
4. Chloride Ion Permeability Based on Charge Passed, ASTM C1202: 800 coulombs maximum.
5. Mortar shall not produce a vapor barrier.

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6. Certified to meet requirements of NSF 61 for contact with potable water.

D. Manufacturers and Products:

1. BASF Construction Chemicals, LLC - Building Systems, Shakopee, MN; MasterEmaco S 211SP.
2. Sika Corp., Lyndhurst, NJ; SIKACEM 103F.
3. Euclid Chemical Co., Cleveland, OH; Eucoshot F, Eucoshot with Tuf-Strand SF added per manufacturer's recommendations.

2.02 REPAIR SYSTEM B – LOW-PRESSURE SPRAY MORTAR

A. One or two-component, cement based, fiber reinforced, shrinkage compensated, gray in color, with a minimum 30-minute working time.

B. Cured materials mixed in accordance with manufacturer's instructions shall conform to the following criteria:

1. Compressive Strength, ASTM C109/C109M at 28 Days: 6,000 psi minimum.
2. Flexural Strength, ASTM C348 at 28 Days: 1,100 psi minimum.
3. Slant Shear Bond Strength, ASTM C882/C882M Test Method Modified with No Bonding Agent, at 28 Days: 3,000 psi minimum.
4. Splitting Tensile Strength, ASTM C496/C496M at 28 Days: 600 psi minimum.
5. Drying Shrinkage, ASTM C157/C157M Modified at 28 Days or ASTM C531: 0.1 percent maximum.
6. Chloride Ion Permeability Based on Charge Passed, ASTM C1202: 1,000 coulombs maximum.
7. System shall not produce a vapor barrier.
8. Certified to meet requirements of NSF 61 for contact with potable water.
9. Sprayable, extremely low permeability, sulfate resistant, easy to use and requiring only addition of water.
10. Free of chlorides and other chemicals causing corrosion.

C. Manufacturers and Products:

1. BASF Construction Chemicals, LLC - Building Systems, Shakopee, MN; MasterEmaco S 488CI.
2. Sika Corp., Lyndhurst, NJ; SikaRepair 224.
3. Euclid Chemical Co., Cleveland, OH; Tamms Structural Mortar.

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2.03 REPAIR SYSTEM C – POLYMER-MODIFIED REPAIR MORTAR

A. Polymer-modified, one- or two-component, cementitious based, chloride resistant, flowable, gray in color, working time of 20 minutes minimum, surface renovation mortar.

B. Cured Mortar Properties:

1. Compressive Strength, ASTM C109/C109M at 28 Days: 7,000 psi minimum.
2. Flexural Strength, ASTM C348 at 28 Days: 1,200 psi minimum.
3. Slant Shear Bond Strength, ASTM C882/C882M Test Method Modified with No Bonding Agent at 28 Days: 2,000 psi minimum.
4. Splitting Tensile Strength, ASTM C496/C496M at 28 Days: 500 psi minimum.
5. Drying Shrinkage, ASTM C596 at 28 Days: 0.12 percent maximum. Not required for small repair areas approximately 1 square foot in area or less.
6. Freeze Thaw Resistance, ASTM C666/C666M, at 300 Cycles: 90 percent RDM.
7. Chloride Ion Permeability Based on Charge Passed, ASTM C1202: 800 coulombs maximum for liquid holding and belowgrade repairs.
8. Certified to meet requirements of NSF 61 for contact with potable water.

C. Manufacturers and Products:

1. BASF Construction Chemicals, LLC - Building Systems, Shakopee, MN; MasterEmaco N 300CI.
2. Sika Corp., Lyndhurst, NJ; SikaTop 123 PLUS.
3. Euclid Chemical Co., Cleveland, OH; DuralTop Gel.

2.04 WATER

A. Clean and free from oil, acid, alkali, organic matter, or other deleterious substances, meeting federal drinking water standards, as specified in Section 03 30 00, Cast-in-Place Concrete.

2.05 REINFORCEMENT

A. Deformed Steel Reinforcement: Per Section 03 21 00, Steel Reinforcement.

B. Mesh Reinforcement: Welded wire fabric flat sheets with spacing of wires and wire size in accordance with ASTM A185/A185M, wire 75 ksi minimum tensile strength per ASTM A82/A82M.

C. Tie Wire: 16-gauge, galvanized.

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D. Mesh Anchors:

1. Manufacturers and Products:
    a. Powers Fastening, Inc., Brewster, NY; Tie Wire Version of Power-Stud.
    b. Hilti Fastener Systems, Tulsa, OK; Kwik Bolt II HHDCA, 1/4-inch ceiling hanger.

2.06 CEMENTITIOUS BONDING AGENT AND REINFORCEMENT COATING

A. Cementitious adhesive, specifically formulated for bonding plastic portland cement concrete or mortar to hardened portland cement concrete.

1. Mixed Bonding Agent Properties:
    a. Pot Life: 75 minutes to 105 minutes.
    b. Contact Time: 24 hours.
    c. Color: Concrete gray.
2. Cured Cementitious Adhesive Properties:
    a. Splitting Tensile Strength, ASTM C496/C496M at 28 Days: 500 psi minimum.
    b. Flexural Strength, ASTM C348: 1,000 psi minimum.
    c. Slant Shear Bond Strength, ASTM C882/C882M at 14 Days:
        1) 2-Hour Open Time: 2,500 psi minimum.
        2) 24-Hour Open Time: 2,000 psi minimum.
3. Bonding agent shall not produce a vapor barrier.
4. Compatible with and from same manufacturer as the repair system used.

B. Manufacturers and Products:

1. BASF Construction Chemicals, LLC - Building Systems, Shakopee, MN; MasterEmaco P 124.
2. Sika Corp., Lyndhurst, NJ; Sika Armatec 110 EpoCem.
3. Euclid Chemical Co., Cleveland, OH: Dural Prep AC.

2.07 EVAPORATION RETARDANT

A. As specified in Section 03 39 00, Concrete Curing.

2.08 CURING COMPOUND

A. As specified in Section 03 39 00, Concrete Curing.

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PART 3 EXECUTION

3.01 GENERAL

A. New Concrete Work: Repair deficiencies in new concrete structures constructed under this Contract with applicable repair system. Refer to Section 03 30 00, Cast-in-Place Concrete.

3.02 APPLICATION

A. General:

1. Repair System A: Large areas and number of repair areas.
2. Repair System B: Medium to large areas and number of repair areas.
3. Repair System C: Small and limited areas and number of repair areas.

3.03 PREPARATION

A. Identify unsound and deteriorated concrete by sounding techniques, or as directed by Engineer, and review proposed extent of repair with Engineer.

B. Remove unsound, honeycombed, deteriorated, or otherwise defective areas of concrete from work areas.

1. Use 8,000 psi minimum high-pressure water blasting machine as required for Site conditions.
2. Remove concrete to abrade substrate concrete surfaces to a minimum amplitude roughness of 3/16 inch measured between high and low points with a 3-foot-long straightedge, in accordance with ASTM D4259.
3. Where final surface is required to be flush with existing adjacent surface remove existing concrete depth as required for application of minimum thickness of repair mortar.

C. Do not use power-driven jackhammers, chipping hammers, or scabblers unless water blasting is not permitted or practical because of Site conditions, or may cause other damage to equipment or facilities. In such cases where chipping hammers are required, limit size of chipping hammer to 16 pounds or lighter, or use small electric chipping hammer, to reduce formation of micro-fractures in substrate concrete surface.

D. Following removal of unsound or deteriorated concrete, check substrate concrete surface by sounding techniques to identify unsound concrete remaining or resulting from use of chipping hammer.

E. Remove unsound concrete to satisfaction of Engineer.

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F. Square edges of patch areas by sawing or chipping to avoid tapered shoulders or featheredges. Avoid cutting embedded steel reinforcement. Roughen polished saw-cut edge by high-pressure water blasting.

G. Remove concrete adjacent to steel reinforcement to a minimum of 1-inch clearance around steel reinforcement for application and bonding of new repair mortar to circumference of exposed steel reinforcement if one or more of the following surface conditions exist:

1. 50 percent or more of circumference around steel reinforcement is exposed during concrete removal.
2. 25 percent or more of circumference around steel reinforcement is exposed during concrete removal and corrosion is present to extent that more than 25 percent loss of section has occurred.
3. Otherwise evident that bond between existing concrete and steel reinforcement has been destroyed or has deteriorated as determined by Engineer.

H. Clean exposed steel reinforcement of loose rust and concrete splatter per recommendations of repair material manufacturer and in accordance with ASTM D4258.

I. Keep areas from which concrete has been removed free of dirt, dust, and water blasting waste slurry. Remove laitance and other bond inhibiting contaminates from prepared areas.

J. Dampen repair areas at least 6 inches beyond area to receive repair mortar for at least 24 hours to provide saturated surface dry (SSD) condition without standing water at time of application of mortar as required by and in accordance with repair mortar manufacturer’s printed instructions.

K. Collect and dispose of spent water and concrete debris from removal operations offsite in manner and location acceptable to Owner.

3.04 REINFORCEMENT INSTALLATION

A. Provide steel reinforcement when existing reinforcement is not exposed, and when mortar application is more than 3 inches deep, unless otherwise shown on Drawings.

B. Replace deteriorated steel reinforcement with new steel reinforcement equivalent in cross-sectional area to original steel reinforcement.

C. Install mesh anchors in accordance with mesh manufacturer’s instructions.

D. Fasten steel reinforcement to mesh anchors with tie wire to prevent from moving during placement of repair mortar.

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E. Lap reinforcement mesh a minimum of one mesh spacing and securely fasten mesh to mesh anchors, or to reinforcement fastened to mesh anchors, with tie wire at intervals no more than 12 inches to prevent movement during application of repair mortar.

3.05 PROTECTION

A. If cementitious coating or bonding agent is used, protect adjacent surfaces from over application. Promptly remove bonding agent applied beyond repair area.

B. Protect adjacent surfaces, and equipment, from being damaged by overshooting, rebound, and dust, as applicable for repair mortar system used, from shotcrete mortar or low-pressure spray mortar.

3.06 REPAIR SYSTEM A – SHOTCRETE MORTAR PLACEMENT

A. Apply shotcrete mortar in accordance with manufacturer's instructions.

B. Do not reuse rebound materials.

C. Apply mortar using dry mix process, in accordance with ACI 506.2.

D. Shotcrete mortar shall emerge from nozzle in a steady, uninterrupted flow. If flow becomes intermittent, direct flow away from the Work until flow of mortar becomes constant.

E. Applied Shotcrete Mortar: Minimum thickness of 1-1/2 inches to 2 inches of cover over existing reinforcement, or to level of surrounding concrete surface, whichever results in thicker coat.

F. Nozzle Position: Hold nozzle approximately at right angles to and at a distance from surface in accordance with shotcrete repair mortar system manufacturer's instructions for type of application, nozzle, and air pressure used.

G. Steel Reinforcement Encasement:

1. Modify procedure of shooting shotcrete mortar to better direct material around reinforcement bars.
2. Prevent shotcrete mortar from building up on reinforcement steel when shooting on, around, through, and behind steel to eliminate voids.
3. Provide dense void-free encasement of reinforcement steel.

H. Shotcreting More than One Layer: In accordance with shotcrete repair mortar system manufacturer's printed instructions.

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I. Apply finish to exposed shotcrete mortar surface to match existing surface and in accordance with manufacturer's instructions.

J. Rebound Removal: Continuously throughout shotcrete mortar application, remove rebound, sand, and miscellaneous debris, and dispose off Site at an approved disposal facility.

K. Cure as specified in Article Curing.

3.07 REPAIR SYSTEM B – LOW-PRESSURE SPRAY MORTAR PLACEMENT

A. Mix mortar in accordance with manufacturer's printed instructions.

B. After priming prepared substrate concrete surface per manufacturer's recommendations, apply mortar by low-pressure spraying equipment, unless noted otherwise.

C. Bonding Agent:

1. Use bonding agent when manufacture required for hand applied areas, in accordance with repair mortar manufacturer's instructions.
2. Application of repair mortar over bonding agent shall be completed within time frame recommended by bonding agent manufacturer.
3. Consult with manufacturer for optimum and minimum acceptable degrees of surface tackiness of coat.

D. Work mortar firmly and quickly into repair area.

E. Finish repair mortar to match adjacent concrete surface.

F. Cure as specified in Article Curing.

3.08 REPAIR SYSTEM C – POLYMER-MODIFIED REPAIR MORTAR PLACEMENT

A. Mix mortar in accordance with manufacturer's printed instructions.

B. Bond Coat: Apply to prepared substrate concrete surface before application of mortar in accordance with repair mortar manufacturer's printed instructions. Do not apply more bond coat than can be covered with mortar before bond coat dries. Do not retemper bond coat.

C. Place mortar by hand or low-pressure spray and trowel to specified surface finish, in accordance with requirements of repair material's printed instructions.

D. Finish repair mortar to match adjacent concrete surface.

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E. Cure as specified in Article Curing, and in accordance with manufacturer's printed instructions.

3.09 CURING

A. Prior to curing, apply water fog to repair mortar system in accordance with repair mortar system manufacturer's printed instructions.

B. Cure in accordance with repair mortar manufacturer's printed instructions.

C. Where permitted by repair mortar manufacturer's printed instructions, continue water fog curing after repair mortar system application and when curing will not cause erosion of mortar.

D. Continuously water cure repair mortar system for a period of 7 days.

E. Do not cure using curing compound or membrane, unless method is part of repair mortar system manufacturer's printed instructions and approval is obtained from Engineer.

F. Cure intermediate layers of repair mortar in accordance with repair mortar manufacturer's printed instructions.

G. Where curing compound is permitted by repair mortar system manufacturer, apply curing compound in accordance with Section 03 39 00, Concrete Curing.

3.10 FIELD QUALITY CONTROL

A. Sounding for Hollow Areas:

1. Light hammer tap repaired areas listening for hollow sound to determine areas that have not properly bonded to substrate concrete.
2. Mark hollow areas for removal and replacement.

B. Compression Strength Test:

1. Test in accordance with ASTM C109/C109M, except modified by making samples using repair mortar.
2. Obtain production samples of mixed wet mortar materials from nozzle, or mixer, during construction for compliance with Specifications for testing at 7 days, and 28 days.
3. Provide a minimum of three samples for each 200 square feet of mortar repair, and a minimum of three samples in total, whichever is greater, for testing.
4. Record location where repair mortar is being applied at time production samples are obtained.

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C. Direct Tension Bond Test:

1. In Situ Bond Testing: Perform tension bond test in accordance with ASTM C1583/C1583M.
2. Record locations on in situ bond tests on each type of applied repair mortar.

D. Testing laboratory retained by Owner will provide the following:

1. Compression Strength Test:
   a. Testing will follow a “modified” ASTM C109/C109M.
   b. A minimum of three production samples of mixed material will be obtained from each 200 square feet of mortar repair, and a minimum of three samples in total, whichever is greater, for testing at 7 days, and 28 days.
   c. Record location where repair mortar is being applied at time production samples are obtained.
2. Direct Tension Bond Test:
   a. Two core samples will be obtained and tested for each 2,000 square feet of repair work.
   b. Cores will be 2-1/2-inch or 3-inch diameter to a total depth equal to at least 2.5 times repair mortar thickness.
   c. Bond Strength of Repair Mortar to Substrate Concrete: 300 psi minimum in direct tension without failure or movement.
   d. Record locations of Bond Tests on each type of applied repair mortar tested.

E. Retest mortar repairs that do not meet test requirements.

F. Repair and fill holes using same repair mortar where core samples have been removed.

3.11 MORTAR REPAIR FAILED TEST

A. Remove and replace unacceptable Work.

B. Hollow Sounding Areas: Saw cut hollow sounding areas to a new square edge. Remove unsound mortar repair. Prepare substrate surface and reapply repair mortar as specified herein above.

C. Failed Compression Strength Test: Remove affected areas of repair mortar represented by failed compression strength test results. Prepare substrate surface and reapply repair mortar as specified herein above.

D. Failed Bond Tests: Remove affected areas of repair mortar represented by failed bond test results. Prepare substrate surface and reapply repair mortar as specified herein above.

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E. Retest areas where repair mortar was removed and replaced, in accordance with test requirements specified herein above.

3.12 MANUFACTURER'S SERVICES

A. Provide repair mortar system manufacturer's representative at Site to review acceptability of surface preparation, mixing and installation assistance, training of repair mortar system applicators, inspection, and Certification of Proper Installation.

3.13 CLEANING

A. Remove overshot shotcrete, Repair System and low-pressure spray, Repair System B repair mortar and rebound materials as the Work proceeds. Remove waste materials, unsound material from concrete surfaces, material chipped from structure, and water used in preparation of or repair areas, finishing, and curing, and dispose offsite at an approved disposal site.

END OF SECTION

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SECTION 03 01 33
REPAIR OF HORIZONTAL CONCRETE SURFACES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Association of State Highway and Transportation Officials (AASHTO): T277, Standard Method of Test for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration.
2. ASTM International (ASTM):
    a. A82/A82M, Standard Specification for Steel Wire, Plain, for Concrete Reinforcement.
    b. A185/A185M, Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete.
    c. A615/A615M, Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
    d. A706/A706M, Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement.
    e. C42/C42M, Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete.
    f. C78/C78M, Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading).
    g. C109/C109M, Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50-mm] Cube Specimens).
    h. C157/C157M, Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete.
    i. C348, Standard Test Method for Flexural Strength of Hydraulic-Cement Mortars.
    j. C469, Standard Test Method for Static Modulus of Elasticity and Poisson's Ratio of Concrete in Compression.
    k. C496/C496M, Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens.
    l. C666/C666M, Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing.
    m. C779/C779M, Standard Test Method for Abrasion Resistance of Horizontal Concrete Surfaces.
    n. C882/C882M, Standard Test Method for Bond Strength of Epoxy-Resin Systems Used with Concrete by Slant Shear.
    o. C928/C928M, Standard Specification for Packaged, Dry, Rapid-Hardening Cementitious Materials for Concrete Repairs.

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p. C1012/C1012M, Standard Test Method for Length Change of Hydraulic-Cement Mortars Exposed to a Sulfate Solution.
q. C1202, Standard Test Method for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration.
r. C1583/C1583M, Standard Test Method for Tensile Strength of Concrete Surfaces and the Bond Strength or Tensile Strength of Concrete Repair and Overlay Materials by Direct Tension (Pull-off Method).
s. D638, Standard Test Method for Tensile Properties of Plastics.
t. D695, Standard Test Method for Compressive Properties of Rigid Plastics.
u. D4258, Standard Practice for Surface Cleaning Concrete for Coating.
v. D4259, Standard Practice for Abrading Concrete.
w. E699, Standard Practice for Evaluation of Agencies Involved in Testing, Quality Assurance, and Evaluating of Building Components.

3. NSF, International (NSF): 61, Standard for Drinking Water System Components – Health Effects.

1.02 DEFINITIONS

A. Abrasive Blasting: Surface preparation method that uses compressed air intermixed with an abrasive medium to clean surface of substrate concrete, exposed steel, and steel reinforcement. Compressed air and abrasive medium is projected at high speed through a nozzle directly at the surface. Method is used to remove corrosion by-products, laitance, or other materials that may inhibit bond of repair concrete.

B. Defective Area: As defined in Section 03 30 00, Cast-in-Place Concrete.

C. High-Pressure Water Blasting (sometimes referred to as hydro-demolition): Uses water that may contain an abrasive medium, projected under high pressure and high velocity. Used for demolition, cutting, partial or full depth removal, cleaning, scarifying, or roughening of concrete surfaces, or removing existing coatings, for preparation of substrate concrete surfaces.

D. New Concrete: As defined in Section 03 30 00, Cast-in-Place Concrete.

1.03 SUBMITTALS

A. Action Submittals:

1. Product data sheets for each material supplied.
2. Drawings supplemented by photographs indicating location, size, estimated quantity, and proposed repair mortar system for each repair location in existing concrete.

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3. Drawings indicating results of sounding for hollow areas including location, size, estimated quantity, of hollow-sounding areas for each repair location.

B. Informational Submittals:

1. Repair Mortar System: Manufacturer's preparation and installation instructions.
2. Written description of equipment proposed for concrete removal and surface preparation.
3. Certificates:
   a. Manufacturer's Certificate of Compliance in accordance with Section 01 61 00, Common Product Requirements, that proposed repair mortar systems meet requirements of ASTM C928/C928M.
   b. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements, that repair mortar systems are prepackaged, shrinkage compensated, specially designed for use on horizontal surfaces that are exposed to potable water, or receive traffic.
   c. Mortar Manufacturer's Certificate of Proper Installation.
   d. Confirmation mortar materials meet requirements of NSF 61.
   e. [H: Confirmation epoxy resin bonding agents conform to ASTM C882/C882M.]
4. Statements of Qualification:
   a. Repair mortar system applicator.
   b. Independent Testing Laboratory.
5. Field and laboratory test results.

1.04 QUALITY ASSURANCE

A. Qualifications:

1. Repair Mortar System Applicator: Trained and experienced applicator endorsed by repair mortar system manufacturer.
2. Repair Mortar System Manufacturer's Representative: Knowledgeable and experienced on technical data and application requirements for specified products.

B. Independent Testing Laboratory: Meet criteria stated in ASTM E699.

C. Pre-repair Conference:

1. Required Meeting Attendees:
   a. Contractor.
   b. Repair Subcontractor.
   c. Technical representative for repair material manufacturer.
   d. Engineer.

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2. Schedule and conduct prior to incorporation of respective products into Project. Notify Engineer of location and time.
3. Agenda shall include, but not limited to:
    a. Review of field conditions. Conduct field observations of the Work to be performed.
    b. Based on above observations, repair material manufacturer's technical representative shall confirm material selection and make Project specific repair method recommendations.
    c. Technical representative for repair material manufacturer shall review proposed surface preparation, material application, consolidation, finishing, curing, and protection of repair material from weather conditions.
    d. Other specified requirements requiring coordination.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Package repair mortar system products in moisture-resistant bags, pails, or moisture-resistant bulk bags.

B. Deliver, store, and handle repair materials in accordance with manufacturer's printed instructions.

PART 2 PRODUCTS

2.01 REPAIR MORTAR SYSTEM NO. 1—MAGNESIUM PHOSPHATE REPAIR MORTAR

A. One or two-component, magnesium-ammonium-phosphate concrete mortar.

B. Compressive Strength, ASTM C109/C109M modified:

1. 1 Hour: 2,000 psi minimum.
2. 3 Hours: 5,000 psi minimum.
3. 1 Day: 6,000 psi minimum.
4. 28 Days: 7,500 psi minimum.

C. Flexural Strength, ASTM C78/C78M Modified (3-inch by 4-inch by 16-inch prism) at 1 Day: 550 psi minimum.

D. Modulus of Elasticity, ASTM C469 at 7 Days: 4.18 by 10^6 psi minimum.

E. Freeze-thaw Resistance and Resistance to Deicing Chemicals, ASTM C666/C666M, Procedure A, at 300 Cycles: 80 percent RDM minimum.

F. Sulfate Resistance, ASTM C1012/C1012M, Length Change after 52 Weeks: 0.09 percent maximum.

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G. Application Temperature Range: 20 degrees F to 85 degrees F for normal weather applications 85 degrees F to 100 degrees F for hot weather applications.

H. Certified to meet requirements of NSF 61 for contact with potable water.

I. Manufacturers and Products:

1. BASF Construction Chemicals, LLC - Building System, Shakopee, MN; MasterEmaco T 545, T 545HT.
2. Euclid Chemical Co., Cleveland, OH; Eucospeed MP, Eucospeed MP Hot Weather.

2.02 REPAIR MORTAR SYSTEM NO. 2—HIGH EARLY STRENGTH REPAIR MORTAR

A. One or two-component, fast-setting, high early strength repair mortar.

B. Compressive Strength, ASTM C109/C109M:

1. 2 Hours: 1,500 psi minimum.
2. 1 Day: 4,500 psi minimum.
3. 7 Days: 8,000 psi minimum.
4. 28 Days: 9,000 psi minimum.

C. Flexural Strength, ASTM C348:

1. 1 Day: 850 psi minimum.
2. 7 Days: 1,000 psi minimum.
3. 28 Days: 1,100 psi minimum.

D. Modulus of Elasticity, ASTM C469:

1. 1 Day: 3.8 by 10^6 psi minimum.
2. 28 Days: 4.5 by 10^6 psi minimum.

E. Slant Shear Bond Strength, ASTM C882/C882M (Modified):

1. 1 Day: 2,500 psi minimum.
2. 7 Days: 2,900 psi minimum.
3. 28 Days: 3,100 psi minimum.

F. Splitting Tensile Strength, ASTM C496/C496M:

1. 1 Day: 850 psi minimum.
2. 7 Days: 1,200 psi minimum.
3. 28 Days: 1,300 psi minimum.

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G. Freeze-thaw Resistance, ASTM C666/C666M, Procedure A, at 300 Cycles: 98 percent RDM.

H. Chloride Ion Permeability Based on Charge Passed, ASTM C1202 or AASHTO T277, 28 Days: 960 coulombs maximum.

I. Certified to meet requirements of NSF 61 for contact with potable water.

J. Manufacturers and Products:

1. BASF Construction Chemicals, LLC - Building Systems, Shakopee, MN; MasterEmaco T 415.
2. Euclid Chemical Co., Cleveland, OH; VersaSpeed.

2.03 REPAIR MORTAR SYSTEM NO. 3—SHRINKAGE COMPENSATED REPAIR MORTAR

A. One or two-component cement-based, flowable, shrinkage compensated repair mortar system.

B. Compressive Strength, ASTM C109/C109M:

1. 1 Day: 2,500 psi minimum.
2. 7 Days: 6,000 psi minimum.
3. 28 Days: 8,000 psi minimum.

C. Flexural Strength, ASTM C348 at 28 Days: 770 psi minimum.

D. Modulus of Elasticity, ASTM C469 at 28 Days: 5.9 by 10^6 psi minimum.

E. Slant Shear Bond Strength, ASTM C882/C882M Modified:

1. 7 Days: 2,150 psi minimum.
2. 28 Days: 3, 000 psi minimum.

F. Freeze-thaw Resistance, ASTM C666/C666M, Procedure A, at 300 Cycles: 97.0 percent RDM.

G. Chloride Ion Permeability Based on Charge Passed, ASTM C1202 at 28 Days: 650 coulombs maximum.

H. Sulfate Resistance, ASTM C1012/C1012M after 6 Months: 0.01 percent length change maximum.

I. Certified to meet requirements of NSF 61 for contact with potable water.

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J. Manufacturers and Products:

1. BASF Construction Chemicals, LLC - Building Systems, Shakopee, MN; MasterEmaco S 466 CI.
2. Euclid Chemical Co., Cleveland, OH; Eucocrete Supreme.

2.04 REPAIR MORTAR SYSTEM NO. 4—METALLIC AGGREGATE REPAIR MORTAR

A. One or two-component cement-based, flowable, metallic-aggregate repair mortar system:

B. Compressive Strength, ASTM C109/C109M:

1. 1 Day: 5,000 psi minimum.
2. 7 Days: 8,800 psi minimum.
3. 28 Days: 12,000 psi minimum.

C. Abrasion Resistance, ASTM C779/C779M, Procedure A: Eight times more wear resistance than plain concrete, 0.017 inch maximum.

D. Density: 215 pound per cubic foot.

E. Certified to meet requirements of NSF 61 for contact with potable water.

F. Manufacturers and Products:

1. BASF Construction Chemicals, LLC - Building Systems, Shakopee, MN; Master T 300.
2. Euclid Chemical Co. (The), Cleveland, OH; Super Euco-Top.

2.05 REPAIR MORTAR SYSTEM NO. 5—POLYMER MODIFIED REPAIR MORTAR

A. One or two-component, fast-setting, polymer modified cementitious based repair mortar system.

B. Compressive Strength, ASTM C109/C109M:

1. 1 Day: 2,500 psi minimum.
2. 7 Days: 5,000 psi minimum.
3. 28 Days: 7,000 psi minimum.

C. Flexural Strength, ASTM C348 at 28 Days: 1,500 psi minimum.

D. Slant Shear Bond Strength, ASTM C882/C882M Modified at 28 Days: 2,000 psi minimum.

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E. Splitting Tensile Strength, ASTM C496/C496M at 28 Days: 600 psi minimum.

F. Abrasion Resistance Depth of Wear, ASTM C779/C779M, Procedure A, at 60 Minutes: 0.033 inch maximum.

G. Drying Shrinkage, ASTM C157/C157M Modified, at 28 Days: 0.09 percent maximum.

H. Rapid Chloride Ion Permeability Based on Charge Passed, ASTM C1202: 28 Days: Under 850 coulombs maximum.

I. Certified to meet requirements of NSF 61 for contact with potable water.

J. Manufacturers and Products:

1. BASF Construction Chemicals, LLC - Building Systems, Shakopee, MN; MasterEmaco T 310 CI.
2. Euclid Chemical Co., Cleveland, OH; Duraltop Flowable Mortar.

2.06 WATER

A. Clean and free from oil, acid, alkali, organic matter, or other deleterious substances, meeting federal drinking water standards, as specified in Section 03 30 00, Cast-in-Place Concrete.

2.07 REINFORCEMENT

A. Deformed Steel reinforcement: Per Section 03 21 00, Steel Reinforcement.

B. Mesh Reinforcement: Welded wire fabric flat sheets with spacing of wires and wire size in accordance with ASTM A185/A185M, wire 75 ksi minimum tensile strength per ASTM A82/A82M, and repair mortar system manufacturer’s recommendations.

C. Tie Wire: 16-gauge, galvanized.

D. Mesh Anchors:

1. Manufacturers and Products:
   a. Powers Fastening, Inc., Brewster, NY; Tie Wire Version of Power-Stud.
   b. Hilti Fastener Systems, Tulsa, OK; Kwik Bolt II HHDCA, 1/4-inch ceiling hanger.

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2.08 CEMENTITIOUS BONDING AGENT AND REINFORCEMENT COATING

A. Cementitious adhesive, specifically formulated for bonding plastic portland cement concrete or mortar to hardened portland cement concrete.

1. Mixed Bonding Agent Properties:
   a. Pot Life: 75 minutes to 105 minutes.
   b. Contact Time: 24 hours.
   c. [B: Color: Concrete gray.]
2. Cured Cementitious Adhesive Properties:
   a. Splitting Tensile Strength, ASTM C496/C496M at 28 Days: 600 psi minimum.
   b. Flexural Strength, ASTM C348: 1,000 psi minimum.
   c. Slant Shear Bond Strength, ASTM C882/C882M:
      1) 2-Hour Open Time: 2,500 psi minimum.
      2) 24-Hour Open Time: 2,000 psi minimum.
3. Bonding agent shall not produce a vapor barrier.
4. Compatible with, and from same manufacturer as the, repair mortar system used.

B. Manufacturers and Products:

1. BASF Construction Chemicals, LLC - Building Systems, Shakopee, MN; MasterEmaco P 124.
2. Sika Corp., Lyndhurst, NJ; Sika Armatec 110 EpoCem.
3. Euclid Chemical Co., Cleveland, OH; Dural Prep AC.

2.09 EPOXY BONDING AGENT

A. Two-component, moisture insensitive, 100 percent solids epoxy resin.

B. Tensile Strength, ASTM D638, at 14 Days: 4,400 psi minimum.

C. Elongation at Break, ASTM D638: 1.49 percent minimum.

D. Compressive Strength, ASTM D695, at 28 Days for Application Temperature of 73 Degrees F to 77 Degrees F: 8,000 psi minimum.

E. Bond Strength, ASTM C882/C882M, at 14 Days: 1,800 psi minimum.

F. Pot Life, at 73 Degrees F to 77 Degrees F: 75 minutes minimum.

G. Manufacturers and Products:

1. BASF Construction Chemicals, LLC - Building Systems, Shakopee, MN; MasterEmaco ADH 326 when ambient temperature is 73 degrees F or higher.

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2.10 EVAPORATION RETARDANT

A. As specified in Section 03 39 00, Concrete Curing.

2.11 CURING COMPOUND

A. As specified in Section 03 39 00, Concrete Curing.

PART 3 EXECUTION

3.01 GENERAL

A. New Concrete Work: Repair deficiencies in new concrete structures constructed under this Contract with applicable repair system.

3.02 APPLICATION

A. General:

1. Repair Mortar System No. 1: Patches, joints, and overlays 1/2 inch to 3 inches thick. Return to service in 1 hour.
2. Repair Mortar System No. 2: Patches, joints, or overlays 1/2 inch to 3 inches thick. Return to service in 3 hours to 7 days.
3. Repair Mortar System No. 3: Patches, joints, or overlays 1 inch thick or greater. Return to service in 7 days or more.
4. Repair Mortar System No. 4: Heavy-duty joints or overlays 2 inches thick or greater. Return to service in 7 days or more.
5. Repair Mortar System No. 5:
    a. Patches and Overlays: 1/4 inch to 3 inches thick.
    b. Return to service for foot traffic in 4 hours; wheel traffic in 7 days.
    c. Working Time: 30 minutes at 70 degrees F.
    d. Application Temperature Range: 45 degrees F to 90 degrees F.

3.03 PREPARATION

A. Identify unsound and deteriorated concrete by sounding techniques, or as directed by Engineer. Review proposed extent of repair with Engineer.

B. Remove unsound, deteriorated, or otherwise defective areas of concrete from Work areas.

1. Use 8,000 psi minimum high-pressure water blasting machine, as appropriate to suit Site conditions.
2. Remove concrete to abrade substrate concrete surface to a minimum amplitude roughness of 3/16 inch measured between high and low

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points with a 3-foot-long straightedge, in accordance with ASTM D4259.

3. Where final surface is required to be flush with existing adjacent surface, remove existing concrete depth as required for application of minimum thickness of repair mortar.

C. Do not use power-driven jackhammers, chipping hammers, scabblers, or scarifiers unless water blasting is not permitted or practical because of Site conditions, or may cause other damage to equipment or facilities. In such cases where chipping hammers are required, limit size of chipping hammer to 16 pounds or lighter, or use small electric chipping hammer, to reduce formation of micro-fractures in substrate concrete surface.

D. Following removal of unsound or deteriorated concrete, check substrate concrete surface by sounding techniques to identify unsound concrete remaining or resulting from use of chipping hammer.

E. Remove unsound concrete to satisfaction of Engineer.

F. Square edges of patch areas by sawing or chipping to avoid tapered shoulders or featheredges. Avoid cutting embedded steel reinforcement. Roughen polished saw-cut edge by high-pressure water blasting.

G. Remove concrete adjacent to steel reinforcement to a minimum of 1-inch clearance around steel reinforcement for application and bonding of new repair mortar to entire circumference of exposed steel reinforcement if one or more of the following surface conditions exist:

1. 50 percent or more of circumference around steel reinforcement is exposed during concrete removal.
2. 25 percent or more of circumference around steel reinforcement is exposed during concrete removal and corrosion is present to extent that more than 25 percent loss of section has occurred.
3. Otherwise evident that bond between existing concrete and steel reinforcement has been destroyed or has deteriorated as determined by Engineer.

H. Clean exposed steel reinforcement of loose rust and concrete splatter per recommendations of repair material manufacturer and in accordance with ASTM D4258.

I. Keep areas from which concrete has been removed free of dirt, dust, and water blasting waste slurry. Remove laitance and other bond inhibiting contaminates from prepared areas.

J. Preparation of Substrate Concrete Surface in Areas to Receive Repair Mortar System Nos. 1,2, 3, and 5: Dampen repair areas at least 6 inches beyond area

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to receive repair mortar for at least 24 hours to provide saturated surface dry (SSD) condition without standing water at time of application of mortar, as required by and in accordance with repair mortar manufacturer's printed instructions.

K. Preparation of Substrate Concrete Surface in Areas to Receive Repair Mortar System No. 4 Repair Mortar: Dry, in accordance with material manufacturer's printed instructions.

L. Spalled Joints:

1. Saw cut edge 1 inch deep and 6 inches back from old joint.
2. Remove unsound concrete and concrete between saw cut and joint.
3. Place wood or fiber spacer to thickness of joint at joint line.

M. Overlays:

1. Square cut edges to a minimum of 1/4 inch deep.
2. Do not feather edge area.
3. Perform special preparation recommended by mortar manufacturer.

N. Collect and dispose of spent water and concrete debris from removal operations offsite in manner and location acceptable to Owner.

3.04 REINFORCEMENT INSTALLATION

A. Provide steel reinforcement when existing steel reinforcement is not exposed and when mortar application is more than 4 inches deep, unless otherwise shown on Drawings.

B. Replace deteriorated steel reinforcement with new steel reinforcement equivalent in cross-sectional area to original steel reinforcement.

C. Install mesh anchors in accordance with mesh manufacturer's instructions.

D. Fasten steel reinforcement to chairs or mesh anchors with tie wire to prevent from moving during placement of repair mortar.

E. Lap reinforcement mesh a minimum of one mesh spacing and securely fasten mesh to mesh anchors, or to steel reinforcement fastened to mesh anchors, with tie wire at intervals no more than 12 inches to prevent movement during application of repair mortar.

F. Coat exposed new and existing steel reinforcement with cementitious reinforcement coating at the same time as substrate concrete is coated, as specified below, per repair mortar and cementitious reinforcement coating manufacturers' printed instructions.

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3.05 PROTECTION

A. If cementitious coating or bonding agent is used, protect adjacent surfaces from over application. Promptly remove bonding agent applied beyond repair area.

B. Protect adjacent surfaces, and equipment from spillage of repair mortar and dust, as applicable for repair mortar system used.

3.06 PLACEMENT

A. Repair Mortar System Nos. 1, 2, 3, and 5:

1. Remove standing and free water from prepared area.
2. Apply bond scrub coat of mortar to prepared surface in accordance with manufacturer's instructions. Do not apply more scrub coat of mortar than can be covered with repair mortar before scrub coat begins drying.
3. Immediately place mixed repair mortar into prepared area from one side to the other side.
4. Work material firmly into bottom and sides of patch to ensure a good continuous bond.
5. Level repair mortar and screed to elevation of existing concrete.
6. Finish to same texture as existing concrete around patch.
7. Repair Mortar System No. 5 screed or use self-leveling mixture to obtain a uniform and plane surface.

B. Repair Mortar System No. 4:

1. Remove free water from prepared area.
2. Apply bonding agent to prepared surface in accordance with manufacturer's instructions. Do not apply more bonding agent than can be covered with mortar before bonding agent cures, past tacky to the touch.
3. Immediately place mixed repair mortar into prepared area from one side to the other side.
4. Work material firmly into bottom and sides of patch to ensure a good continuous bond.
5. Level repair mortar and screed to elevation of existing concrete.
6. Finish to same texture as existing concrete around patch.

C. Joint Repair:

1. Remove joint spacer when repair mortar is hard enough that a pointed trowel will penetrate surface less than 1/2 inch.
2. When repair mortar is cured and ready for use, fill joint in accordance with repair mortar system manufacturer's instructions.

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3.07 FINISHING

A. Spray full strength evaporation retardant on fresh concrete to prevent rapid drying during hot and windy weather.

3.08 CURING

A. Repair Mortar System No. 1:

1. No curing is required.
2. Protect from rain immediately after placing.
3. Liquid-membrane curing compounds or plastic sheeting may be used in accordance with repair mortar manufacturer's instructions to protect the surface from precipitation.
4. Never wet cure.

B. Repair Mortar System Nos. 2, 3, 4, or 5: Apply curing compound in accordance with Section 03 39 00, Concrete Curing.

3.09 FIELD QUALITY CONTROL

A. Sounding for Hollow Areas:

1. Chain drag or light hammer tap repaired areas listening for hollow sound to determine areas that have not properly bonded to substrate concrete.
2. Mark hollow areas for removal and replacement.

B. Compression Strength Test:

1. Test in accordance with ASTM C109/C109M, except modified by making samples using repair mortar.
2. Obtain production samples of mixed materials from mixer during construction for compliance with Specifications.
3. Provide minimum of three samples for each 200 square feet of mortar repair, and a minimum of three samples in total, whichever is greater for testing.
4. Record location where repair mortar is being applied at time production samples are obtained.

C. Direct Tension Bond Test:

1. In Situ Bond Testing: Perform tension bond test in accordance with ASTM C1583/C1583M.
2. Record locations on in situ bond tests on each type of applied repair mortar.

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D. Testing laboratory retained by Owner will provide the following:

1. Compression Strength Test:
   a. Testing will follow a “modified” ASTM C109/C109M.
   b. A minimum of three production samples of mixed material will be obtained from each 200 square feet of mortar repair, and a minimum of three samples in total, whichever is greater, for testing at 7 days, and 28 days.
   c. Record location where repair mortar is being applied at time production samples are obtained.
2. Direct Tension Bond Test:
   a. Two core samples will be obtained and tested for each 2,000 square feet of repair work.
   b. Cores will be 2-1/2-inch or 3-inch diameter to a total depth equal to at least 2.5 times repair mortar thickness.
   c. Bond Strength of Repair Mortar to Substrate Concrete: 300 psi minimum in direct tension without failure or movement.
   d. Record locations of bond tests on each type of applied repair mortar tested.

E. Retest mortar repairs that do not meet test requirements.

F. Repair and fill holes using same repair mortar where core samples have been removed.

3.10 MORTAR REPAIR FAILED TEST

A. Remove and replace unacceptable Work.

B. Hollow Sounding Areas: Saw cut hollow sounding areas to a new square edge, remove unsound mortar repair. Prepare substrate surface and reapply repair mortar as specified herein above.

C. Failed Compression Strength Test: Remove affected areas of repair mortar represented by failed compression strength test results. Prepare substrate surface and reapply repair mortar as specified herein above.

D. Failed Bond Tests: Remove affected areas of repair mortar represented by failed bond test results. Prepare substrate surface and reapply repair mortar as specified herein above.

E. Retest areas where repair mortar was removed and replaced, in accordance with test requirements specified herein above.

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3.11 MANUFACTURERS' SERVICES

A. Provide mortar manufacturer's representative at Site to advice on product selection, review acceptability of surface preparation, mixing and installation assistance, inspection, and Certification of Proper Installation.

3.12 CLEANING

A. Remove excess repair mortar materials as the Work proceeds. Remove waste materials, unsound material from concrete surfaces, material chipped from structure, and water used in preparation of repair areas, finishing, and curing, and dispose offsite at approved disposal site.

END OF SECTION

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SECTION 03 10 00
CONCRETE FORMING AND ACCESSORIES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Concrete Institute (ACI):
   a. 117, Specification for Tolerances for Concrete Construction and Materials.
   b. 301, Specifications for Structural Concrete.
   c. 318, Building Code Requirements for Structural Concrete and Commentary.
2. NSF International (NSF): 61, Drinking Water System Components - Health Effects.

1.02 DEFINITIONS

A. Architectural Concrete: See definition in Section 03 30 00, Cast-in-Place Concrete.

B. Defective Areas: See definition in Section 03 30 00, Cast-in-Place Concrete.

C. Exposed Concrete: See definition in Section 03 30 00, Cast-in-Place Concrete.

1.03 DESIGN REQUIREMENTS

A. Design formwork in accordance with ACI 301 and ACI 318 to provide concrete finishes specified in Section 03 30 00, Cast-in-Place Concrete.

B. When high-range water reducer (superplasticizer) is used in concrete mix, form design shall account for increased hydrostatic pressures.

C. Joints in forms shall be watertight.

D. Limit panel deflection to 1/360th of each component span to achieve tolerances specified.

1.04 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Formwork drawings sealed by a licensed professional engineer, where required by state professional engineering regulations.

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2. Product Data:
    a. Form release agent.
    b. Form ties.
    c. Products to be used for sealing tie holes.

B. Informational Submittals: Statement of qualifications for formwork designer.

1.05 QUALITY ASSURANCE

A. Qualifications:

1. Formwork Designer: Where required by state professional engineering regulations, formwork, falsework, and shoring design shall be designed by an engineer licensed in the state of Project.

PART 2 PRODUCTS

2.01 FORM MATERIALS

A. Wall Forms and Underside of Slabs and Beams:

1. Materials: Plywood, hard plastic finished plywood, overlaid waterproof particle board, or steel in "new and undamaged" condition, of sufficient strength and surface smoothness to produce specified finish.
2. Where steel forms are used, treat steel surfaces to prevent rusting using products approved for use on steel forms.

B. Column Forms:

1. Rectangular Columns: As specified for walls.
2. Circular Columns: Fabricated steel or fiber-reinforced plastic with bolted sections or spirally wound laminated fiber form. Internally treat with release agent for full height of column.

C. Sandblasted Surface Forms: Medium density overlay plywood for flat concrete surfaces to be sandblasted.

D. Painted Surface Forms: High-density overlay plywood for flat concrete surfaces to be painted.

E. All Other Forms: Materials as specified for wall forms.

2.02 ACCESSORIES

A. Form Release Agent:

1. Material:
    a. Shall not bond with, stain, or adversely affect concrete surfaces.

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b. Shall not impair subsequent treatments of concrete surfaces when applied to forms.
c. Ready-to-use water based material formulated to reduce or eliminate surface imperfections.
d. Contain no mineral oil or organic solvents.

2. Manufacturers and Products: Not for surfaces exposed to potable water.
   a. BASF, Shakopee, MN; MBT MasterFinish RL 211.
   b. Cresset Chemical Company; Crete-Lease 20-VOC-Xtra.
3. Manufacturers and Products: For use with potable water structures. Environmentally safe, meeting local, state, and federal regulations and usable in potable water facilities. Certified as meeting NSF 61.
   a. Atlas Tech Products; Atlas Bio-Guard.
   b. Dayton Superior; Dayton Bio-Release EF.
   c. Hill and Griffith Company; Grifcote LV-50-Plus.

B. Rustication Grooves and Beveled Edge Corner Strips: Nonabsorbent material, compatible with form surface, fully sealed on all sides prohibiting loss of paste or water between the two surfaces.

C. Form Snap-Ties:

1. Material: Stainless steel.
2. Spreader Inserts:
   a. Conical or spherical type.
   b. Design to maintain positive contact with forming material.
   c. Furnish units that will leave no metal closer than 1.5 inches to concrete surface when forms, inserts, and tie ends are removed.
3. Wire ties not permitted.
4. Flat bar ties for panel forms; furnish plastic or rubber inserts with minimum 1.5-inch depth and sufficient dimensions to permit patching of tie hole.

D. Form Snap-Ties with Water Stop: For water-holding structures, basements, pipe galleries, and accessible spaces below finish grade, furnish one of the following:

1. Integral steel waterstop 0.103-inch thick and 0.625-inch diameter tightly and continuously welded to tie.
2. Neoprene waterstop 3/16-inch thick and 15/16-inch diameter whose center hole is one half diameter of tie, or molded plastic water stop of comparable size.
3. Orient waterstop perpendicular to tie and symmetrical about center of tie.
4. Design ties to prevent rotation or disturbance of center portion of tie during removal of ends and to prevent water leaking along tie.

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E. Through-Bolts:

1. At Contractor's option, may be used as alternate to form snap-tie or form snap-tie with waterstop.
2. Tapered minimum 1-inch diameter at smallest end.
3. Elastic Vinyl Plug For Through-Bolt Tie Holes:
   a. Design and size of plug to allow insertion with tool to enable plug to elongate and return to original length and diameter upon removal; forms watertight seal.
   b. Manufacturers and Products:
      1) Dayton Superior, Miamisburg, OH; A58 Sure Plug.
      2) Greenstreak Group, Inc., St Louis, MO; X-Plug.

PART 3 EXECUTION

3.01 FORM SURFACE PREPARATION

A. Prior to coating surface, thoroughly clean form surfaces that will be in contact with concrete or that have been in contact with previously cast concrete, dirt, and other surface contaminants.

B. Exposed Wood Forms in Contact with Concrete: Apply form release agent as recommended by manufacturer.

C. Steel Forms: Apply form release agent as soon as they are cleaned to prevent discoloration of concrete from rust.

3.02 ERECTION

A. General: In accordance with ACI 301, unless otherwise specified.

B. Beveled Edges (Chamfer):

1. Form 3/4-inch bevels at concrete edges, unless otherwise shown.
2. Where beveled edges on existing adjacent structures are other than 3/4 inch, obtain Engineer's approval of size prior to placement of beveled edge.

C. Wall Forms:

1. Do not reuse forms with damaged surfaces.
2. Locate form ties and joints in uninterrupted uniform pattern.
3. Inspect form surfaces prior to installation to ensure conformance with specified tolerances.

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D. Curb, Sidewalk, and Driveway Forms:

1. Provide standard steel or wood forms.
2. Set forms to true lines and grades, and securely stake in position.

E. Form Tolerances: Provide forms in accordance with ACI 117 and ACI 318, and the following tolerances for finishes specified:

1. See the Schedule of Concrete Finishes in Section 03 30 00, Cast-in-Place Concrete, for beam, column, and wall types related to required form tolerances.
2. Wall Tolerances:
    a. Straight Vertical or Horizontal Wall Surface: Flat planes within tolerance specified.
    b. Wall Type W-A:
        1) Plumb within 1/4 inch in 10 feet or within 1 inch from top to bottom for walls over 40 feet high.
        2) Depressions in Wall Surface: Maximum 5/16 inch when 10-foot straightedge is placed on high points in all directions.
    c. Wall Type W-B:
        1) Plumb within 1/8 inch in 10 feet or within 1/2 inch from top to bottom for walls over 40 feet high.
        2) Depressions in Wall Surface: Maximum 1/8 inch when 10-foot straightedge is placed on high points in all directions.
    d. Thickness: Maximum 1/4 inch minus or 1/2 inch plus from dimension shown.
    e. Form Offset: Between adjacent pieces of formwork, facing material shall not exceed 1/8 inch for architectural concrete, otherwise 1/4 inch.
3. Beams and Columns Tolerances:
    a. Exposed Straight Horizontal and Vertical Surfaces: Flat planes within tolerances specified.
    b. Lateral Alignment:
        1) Centerlines shall be within plus or minus 1/2 inch from dimensions shown.
        2) At intersections, centerlines shall intersect within plus or minus 1/2 inch of dimensions shown.
    c. Beam Type B-A:
        1) Physical Dimensions: Maximum 1/4 inch minus or 1/2 inch plus from dimension shown.
        2) Elevations: Within plus or minus 1/2 inch, except where tops of beams become part of finished slab. In this case refer to slab tolerances.

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d. Column Type C-A:
   1) Physical Dimensions: Maximum 1/4 inch minus or 1/2 inch plus from dimension shown.
   2) Plumb within 1/4 inch in 10 feet in all directions with maximum 1/2 inch out-of-plumb at top with respect to bottom.

3.03 FORM REMOVAL

A. Nonsupporting forms, sides of beams, walls, columns, and similar parts of Work, may be removed after cumulatively curing at not less than 50 degrees F for 24 hours from time of concrete placement if:

   1. Concrete is sufficiently hard so as not to sustain damage by form removal operations.
   2. Curing and protection operations are maintained.

B. Elevated Structural Slabs or Beams: In accordance with ACI 318, Chapter 6, and at such time as concrete has reached compressive strength equal to 80 percent of specified 28-day compressive strength as determined by test cylinders.

C. Form Ties: Remove conical inserts or through bolts and plug holes as specified in Section 03 30 00, Cast-in-Place Concrete.

3.04 MANUFACTURER'S SERVICES

A. Provide form liner manufacturer's representative at Site for installation assistance, and inspection.

3.05 FIELD QUALITY ASSURANCE AND QUALITY CONTROL

A. Owner-Furnished Quality Assurance, in accordance with IBC Chapter 17 requirements, is provided in Statement of Special Inspections Plan on Drawings Contractor responsibilities and related information are included in Section 01 45 33, Special Inspection, Observation, and Testing.

B. Contractor-Furnished Quality Control: Inspection and testing as required in Section 01 45 16.13, Contractor Quality Control.

END OF SECTION

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SECTION 03 15 00
CONCRETE JOINTS AND ACCESSORIES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   a. A36/A36M, Specification for Carbon Structural Steel.
   b. A615/A615M, Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
   c. A653/A653M, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
   d. A767/A767M, Specification for Zinc-Coated (Galvanized) Steel Bars for Concrete Reinforcement.
   e. C920, Specification for Elastomeric Joint Sealants.
   f. D226, Specification for Asphalt-Saturated Organic Felt Used in Roofing and Waterproofing.
   g. D227, Specification for Coal-Tar Saturated Organic Felt Used in Roofing and Waterproofing.
   h. D994, Specification for Preformed Expansion Joint Filler for Concrete (Bituminous Type).
   i. D1056, Specification for Flexible Cellular Materials—Sponge or Expanded Rubber.
   j. D1171, Standard Guide for Evaluating Nonwoven Fabrics.
   k. D1751, Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types).
   l. D1752, Specification for Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction.
   m. D2240, Standard Test Method for Rubber Property – Durometer Hardness.
2. Corps of Engineers (COE): CRD-C-572, Corps of Engineers Specifications for Polyvinylchloride Waterstop.
3. NSF International (NSF): 61, Drinking Water System Components - Health Effects.

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1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Waterstop: Details of splices, method of securing and supporting waterstop in forms to maintain proper orientation and location during concrete placement.
   b. Construction Joints, Expansion Joints and Control Joints: Layout and location for each type. Include joints locations shown on Drawings, additional required joint locations and any proposed alternate locations.
2. Product Data:
   a. Waterstops.
   b. Bond breaker.
   c. Premolded joint fillers.
   d. Pourable joint fillers.
   e. Preformed control joints.
   f. Epoxy-coated dowels.
   g. Roofing felt.
   h. Accessories not specified in other sections.

B. Informational Submittals:

1. Certification:
   a. Joint Filler(s) for Potable Water Structures: Confirmation material is certified to meet requirements of NSF 61.
   b. Letter stating compatibility between liquids being contained and materials used for:
      1) Waterstops.
      2) Joint fillers.
   c. Manufacturer's application instructions for:
      1) Bonding agent.
      2) Bond breaker.
2. Manufacturer's written instructions for product shipment, storage, handling, installation/application, and repair for:
   a. Waterstops.
   b. Bond breaker.
   c. Bonding agent.
   d. Premolded joint fillers.
   e. Pourable joint fillers (sealant proportions not required as products used only as a filler).
   f. Preformed control joints.

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1.03 DELIVERY, STORAGE, AND HANDLING

A. Acceptance at Site: Verify delivered materials are in accordance with Specifications, regulatory agencies, and Manufacturer's product data sheets prior to unloading and storing onsite.

B. Storage: Store materials under tarps to protect from oil, dirt, and sunlight or as required by Manufacturer.

PART 2 PRODUCTS

2.01 PLASTIC WATERSTOP

A. Extruded from elastomeric plastic compound of which basic resin shall be prime virgin polyvinyl chloride (PVC). Compound shall not contain scrapped material, reclaimed material, or pigment.

B. Specific Gravity: Approximately 1.37.

C. Shore Durometer Type A Hardness: Approximately 80.

D. Performance Requirements: COE Specification CRD-C-572.

E. Type Required in All Expansion, Contraction, and Control Joints: 6 inches wide or 9 inches wide with center bulb and parallel longitudinal ribs or protrusions on each side of strip center, as indicated on Drawings.

F. Type Required in Construction Joints: Flat ribbed, 6 inches wide or 9 inches wide with parallel longitudinal ribs or protrusions on each side of strip center. Center bulb is optional.

G. Corrugated or tapered type waterstops are not acceptable.

H. Thickness: Constant from bulb edge (or center of waterstop) to outside stop edge.

I. Minimum Weight per Foot of Waterstop:

1. 0.50 pound for 3/16 inch by 4 inches.
2. 1.60 pounds for 3/8 inch by 6 inches.
3. 2.30 pounds for 3/8 inch by 9 inches.

J. Factory Fabrications: Use only factory fabrications for intersections, transitions, and changes of direction.

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K. Manufacturers and Products for Center Bulb Type:

1. Use same manufacturers for flat ribbed profile:
   a. Vinylex Corp., St Louis, MO.; No. RB638H (6 inches by 3/8 inch) and No. RB938H (9 inches by 3/8 inch).
   b. Greenstreak, St. Louis, MO; Style No. 702, (4 inches by 3/16 inch), Style 732 (6 inches by 3/8 inch) and Style 735 (9 inches by 3/8 inch).
   c. Durajoint, Garrettsville, OH.; Type 3, (4 inches by 3/16 inch,), Type 9 (6 inches by 3/8 inch), and Type 10 (9 inches by 3/8 inch).
   d. BoMetals, Carrollton, GA.: No. RCB-4316LB (4 inches by 3/16 inch), No. RCB-638LB (6 inches by 3/8 inch) and No. RCB-938NT (9 inches by 3/8 inch).
   e. Dacon Plastics LLC, Jacksonville, TX; No. RCB11, (4 inches by 3/16 inch), No. RCB17 (6 inches by 3/8 inch) and No. RCB18 (9 inches by 3/8 inch).

2.02 WIRE LOOPED PLASTIC WATERSTOP

A. Furnish as alternative to plastic waterstops.

B. Same material and geometry as plastic waterstops.

C. Furnish with continuous galvanized wire looping at edge for convenience in positioning and securing stop in place in forms.

D. Manufacturer and Product: Paul Murphy Plastics, Roseville, MI; “Wire Stop Waterstop”; geometry numbers ACR 6380, ACR 9380, as shown on Paul Murphy Plastics Co. Drawing No. CCP-120-12M.

2.03 HYDROPHILIC WATERSTOP

A. For use at construction joints only, where new concrete is placed against existing concrete and as shown on Drawings.

B. Material shall be a nonbentonite hydrophilic rubber compound.

C. Manufacturers and Products:

1. Greenstreak Plastic Products, St. Louis, MO; Hydrotite CJ-1020-2K with Leakmaster LV-1 adhesive and sealant.
2. Adeka Ultra Seal, JLM Associates, Spearfish, SD; MC-2010M with 3M-2141 adhesive and P-201 sealant.

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2.04 BOND BREAKER

A. Tape for Joints: Adhesive-backed glazed butyl or polyethylene tape. Same width as joint that will adhere to premolded joint material or concrete surface.

B. Use bond prevention material as specified in Section 03 30 00, Cast-in-Place Concrete, except where bond breaker tape is specifically called for on Drawings.

2.05 PREMOLDED JOINT FILLER

A. Bituminous Type: ASTM D994 or ASTM D1751.

B. Sponge Rubber:

1. Neoprene, closed-cell, expanded; ASTM D1056, Type 2C5, with compression deflection, 25 percent deflection (limits), 119 kPa to 168 kPa (17 psi to 24 psi) minimum. Use in joints for potable and nonpotable water containment structures.
2. Manufacturer and Product: Monmouth Rubber and Plastics, Corp, Long Branch, NJ; Durafoam DK5151.

2.06 BUILDING PREFORMED CONTROL JOINT

A. One-Piece, Flexible, Polyvinyl Chloride Joint Former:

1. Manufacturer and Product: WR Meadows, Inc., Hampshire, IL; Keyway.

B. One-Piece Galvanized Steel Strip with Preformed Groove:

1. Manufacturer and Product: BoMetals, Inc. Carrollton, GA; QuickKey or ProKey Joint.

C. Furnish in full-length, unspliced pieces.

2.07 POURABLE JOINT FILLERS

A. General:

1. Although product is a sealant, it is being specified as a filler to prevent debris accumulation and allow expansion and contraction under shrinkage and thermal loads. It does not need to meet proportional sealant geometry requirements.
2. For Potable Water Containment structures, meet requirements of NSF 61.

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B. Filler for Potable or Non-Potable Water Containment Structures:

1. Multicomponent sealant, self-leveling or nonsag as required for level, sloping, or vertical joints.
2. Color: White.
3. Manufacturer and Product: Sika Corp., Lyndhurst, NJ; Sikaflex-2c SL.

C. Filler for Nonpotable Water Containment Structures Only:

1. Pourable, two-component, cold-applied compound meeting ASTM C920, Type M, Grade P, Class 25, Use T.
2. Color: Black.
3. Manufacturer and Product: W.R. Meadows, Inc., Elgin, IL; Gardox.

2.08 STEEL EXPANSION JOINT DOWELS

A. Dowels: ASTM A36/A36M round smooth steel bars.

B. Bar Coating: As specified in Section 09 90 00, Painting and Coating, with factory-applied epoxy coating and factory or field applied lubrication coating.

2.09 ACCESSORIES

A. Joint Sealant: Polyurethane as specified in Section 07 92 00, Joint Sealants.

B. One-Part Polyurethane, Immersible:

1. Polyurethane base, single-component, moisture curing; ASTM C920, Type S, Grade NS or P, Class 25.
2. Capable of being continuously immersed in water.
3. Manufacturers and Products for Nonsag:
   a. Sika Chemical Corp.; Sikaflex-1a.
   b. Tremco; Vulkem 116.
4. Manufacturers and Products for Self-leveling:
   a. BASF; Sonneborn, SL-1.
   b. Tremco; Vulkem 45.
   c. Sika Chemical Corp.; Sikaflex 1c SL.

C. Roofing Felt: ASTM D226, Type II, 30-pound asphalt-saturated or equal weight of ASTM D227 coal-tar saturated felt.

D. Steel Reinforcement: As specified in Section 03 21 00, Steel Reinforcement.

E. Nails: Galvanized, as required for securing premolded joint filler.

F. Galvanized Rebar at Control Joints: ASTM A767/A767M and ASTM A615/A615M Grade 60 prior to galvanizing.

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G. Ties for PVC Waterstop: “Hog Rings” or grommets for each edge at 12-inch maximum spacing.

PART 3 EXECUTION

3.01 GENERAL

A. Commence concrete placement after joint preparation is complete.

B. Time Between Concrete Pours: As specified in Section 03 30 00, Cast-in-Place Concrete.

3.02 SURFACE PREPARATION

A. Construction Joints: Prior to placement of abutting concrete, clean contact surface.

1. Remove laitance and spillage from steel reinforcement and dowels.
2. Roughen surface to minimum of 1/4-inch amplitude:
   a. Sandblast after concrete has fully cured.
   b. Water blast after concrete has partially cured.
   c. Green cut fresh concrete with high-pressure water and hand tools.
3. Perform cleaning so as not to damage waterstop, if one is present.

B. Expansion Joint:

1. Use wire brush or motorized device to mechanically roughen and thoroughly clean concrete surfaces on each side of joint from plastic waterstop to top of joint.
2. Use dry, high-pressure air to remove dust and foreign material, and dry joint.
3. Prime surfaces as required before placing joint filler.
4. Avoid damage to waterstop.

C. Contraction Joint and Control Joint:

1. Coat concrete surfaces above and below plastic waterstop with bond breaker.
2. Do not damage or coat waterstop.

D. Construction Joint with Hydrophilic Waterstop:

1. Follow hydrophilic waterstop manufacturer’s written instructions.
2. Clean debris, dirt, dust, and foreign material from concrete surface. Concrete surface must be smooth, clean, and dry. Grind concrete as required.

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3.03 INSTALLATION OF WATERSTOPS

A. General:

1. Continuous waterstop shall be installed in all construction joints in walls and slabs of water holding basins and channels and in walls of belowgrade structures, unless specifically noted otherwise.
2. Join waterstop at intersections to provide continuous seal.
3. Center waterstop on joint.
4. Secure waterstop in correct position. Tie waterstop to steel reinforcement using grommets, “Hog Rings,” or tiewire at maximum spacing of 12 inches. Do not displace waterstop during concrete placement.
5. Repair or replace damaged waterstop.
6. Place concrete and vibrate to obtain impervious concrete in vicinity of joints.
7. Joints in Footings and Slabs:
    a. Ensure that space beneath horizontal waterstop is completely filled with concrete.
    b. During concrete placement, make visual inspection of waterstop area.
    c. Limit concrete placement to elevation of waterstop in first pass, vibrate concrete under waterstop, lift ribbed waterstop to confirm full consolidation without voids, then place remaining concrete to full height of slab.

B. Plastic Waterstops:

1. Install in accordance with manufacturer’s written instructions.
2. Splice in accordance with waterstop manufacturer’s written instructions using Teflon-coated thermostatically controlled heating iron at approximately 380 degrees F.
    a. Allow at least 10 minutes before new splice is pulled or strained in any way.
    b. Finished splices shall provide cross section that is dense and free of porosity with tensile strength of not less than 80 percent of unspliced materials.
    c. Use only factory made waterstop fabrications for all intersections, changes of directions and transitions.
    d. Field splice permitted only for straight butt welds.
3. Wire looped plastic waterstop may be substituted for plastic waterstop.

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C. Hydrophilic Waterstop:

1. Install in accordance with manufacturer's written instructions.
2. Provide minimum of 2-1/2 inches of concrete cover over waterstop. When structure has two layers of steel reinforcement, locate centered between layers of steel or as shown.
3. Apply adhesive to concrete surface and allow to dry for specified time before applying waterstop strip.
4. Lap ends of waterstop strip together at splices and corners and join with sealant.
5. Verify that waterstop is anchored firmly in place before placing concrete. Do not allow vibrator to come into contact with waterstop.
6. Lap hydrophilic waterstop 2 feet minimum with intersecting plastic waterstops.

3.04 EXPANSION JOINT INSTALLATION

A. Premolded Joint Filler:

1. Sufficient in width to completely fill joint space where shown.
2. Install per manufacturer's written instructions.
3. If waterstop is in joint, cut premolded joint filler to butt tightly against waterstop and concrete face.
4. Precut premolded joint filler to required depth at locations where joint filler or sealant is to be applied.
5. Form cavities for joint filler with either precut, premolded joint filler, or smooth removable accurately shaped material. Entire joint above waterstop, in slabs, shall be formed and removed so that entire space down to waterstop can be filled with the pourable joint filler.
6. Vibrate concrete thoroughly along joint form to produce dense, smooth surface.

B. Bituminous Type Premolded Joint Filler:

1. Drive nails approximately 1 foot 6 inches on center through filler, prior to installing, to provide anchorage embedment into concrete during concrete placement.
2. Secure premolded joint filler in forms before concrete is placed.

C. Sponge Rubber Joint Filler: Install per manufacturer's written instructions.

D. Pourable Joint Filler:

1. General:
   a. Install in accordance with the manufacturer's written instructions, except as specified below:
      1) Apply primer prior to pouring joint filler.

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2) Fill entire joint above the waterstop with joint filler as shown.
3) Use masking tape on top of slabs at sides of joints; clean spillage. Remove masking tape afterwards.
4) Sealant products used as fillers need not meet sealant geometry parameters. Do not use backing rods.

E. Steel Expansion Joint Dowels:

1. Install coated and lubricated bars parallel to wall or slab surface and in true horizontal position perpendicular to joint in both plan and section view, so as to permit joint to expand or contract without bending dowels.
2. Secure dowels tightly in forms with rigid ties.
3. Install steel reinforcement in concrete as shown.

3.05 CONTRACTION JOINT INSTALLATION

A. Place bond breaker above and below waterstop.

B. Vibrate concrete thoroughly along the joint form to produce a dense, smooth surface. Do not roughen surface.

3.06 CONTROL JOINT INSTALLATION

A. Locate galvanized steel reinforcement as shown.

B. Install waterstop.

C. Vibrate concrete thoroughly along the joint form to produce a dense, smooth surface. Do not roughen surface.

D. Install bond breaker to concrete surfaces above and below waterstop.

3.07 PREFORMED CONTROL JOINTS

A. Use only where specifically shown; do not use in water-holding basins.

B. Locate slightly below top of slab.

C. Install in accordance with manufacturer’s written instructions in straight, full-length pieces.

D. Steel Strip Type with Preformed Groove: Brace to withstand pressure of concrete during and after placement using only approved stakes and other secondary installation materials.

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3.08 MANUFACTURER'S SERVICES

A. Provide manufacturer's representative at Site for installation assistance, inspection, and certification of proper installation for products specified.

3.09 FIELD QUALITY ASSURANCE AND QUALITY CONTROL

A. Owner-Furnished Quality Assurance, in accordance with IBC Chapter 17 requirements, is provided in the Statement of Special Inspections Plan on Drawings. Contractor responsibilities and related information are included in Section 01 45 33, Special Inspection, Observation, and Testing.

B. Contractor-Furnished Quality Control: Inspection and testing as required in Section 01 45 16.13, Contractor Quality Control.

END OF SECTION

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SECTION 03 21 00
STEEL REINFORCEMENT

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Concrete Institute (ACI):
   a. 318, Building Code Requirements for Structural Concrete and Commentary.
   b. SP-66, Detailing Manual.
2. American Welding Society (AWS): D1.4/D1.4M, Structural Welding Code - Reinforcing Steel.
3. ASTM International (ASTM):
   a. A82/A82M, Standard Specification for Steel Wire, Plain, for Concrete Reinforcement.
   b. A185/A185M, Standard Specification for Steel Welded Wire Reinforcement, Plain, for Concrete.
   c. A497/A497M, Standard Specification for Steel Welded Wire Reinforcement, Deformed, for Concrete.
   d. A615/A615M, Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
   e. A767/767M, Standard Specification for Zinc-Coated (Galvanized) Steel bars for Concrete Reinforcement.
4. Concrete Reinforcing Steel Institute (CRSI):
   a. Placing Reinforcing Bars.
   b. Manual of Standard Practice.
5. International Code Council (ICC): Evaluation Services Report.
6. Wire Reinforcement Institute (WRI): WWR-500, Manual of Standard Practice, Structural Welded Wire Reinforcement.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings prepared in accordance with CRSI Manual of Standard Practice and ACI SP-66:
   a. Bending lists.
   b. Placing drawings.
2. Welded, metallic sleeve splice, and mechanical threaded connection.

B. Informational Submittals:

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1. Lab test reports for steel reinforcement showing stress-strain curves and ultimate strengths.
2. Mechanical Threaded Connections:
    a. Current ICC Evaluation Services Report or equivalent code agency report listing findings to include acceptance, special inspection requirements, and restrictions.
    b. Verification device threads have been tested and meet requirements for thread quality, in accordance with manufacturer's published methods.
    c. Manufacturer's instructions.
3. Welding Qualification: Prior to welding, submit welder qualifications and nondestructive testing procedures in accordance with Section 05 05 23, Welding.
4. Test results of field testing.

1.03 QUALITY ASSURANCE

A. Welder Qualifications: Certified in accordance with AWS D1.4/D1.4M.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Unload, store, and handle bars in accordance with CRSI publication "Placing Reinforcing Bars."

PART 2 PRODUCTS

2.01 MATERIALS

A. Reinforcing Bars:

1. Includes stirrups, ties, and spirals.
2. ASTM A615/A615M, Grade 60, where welding is not required.
3. ASTM A706/A706M, Grade 60, for reinforcing to be welded.
4. ASTM A767/767M, Grade 60, for galvanized bars.

B. Mechanical Splices and Connections:

1. Metal Sleeve Splice:
    a. Furnish with cast filler metal, capable of developing, in tension or compression, 125 percent of minimum tensile strength of bar.
    b. Manufacturer and Product: Erico Products, Inc., Cleveland, OH; Cadweld T-Series.
2. Mechanical Threaded Connections:
    a. Furnish metal coupling sleeve with internal threads engaging threaded ends of bars developing in tension or compression 125 percent of yield strength of bar.
    b. Manufacturers and Products:

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1) Erico Products, Inc., Cleveland, OH; Lenton Reinforcing Steel Couplers.
2) Erico Products, Inc., Cleveland, OH; Lenton Lock Mechanical Rebar Splicing System.
3) Richmond Screw Anchor Co., Inc., Fort Worth, TX; Richmond DB-SAE Dowel Bar Splicers.

C. Welded Wire Fabric:

1. ASTM A185 or ASTM A497 and ACI 318, using ASTM A82 wire of 75 ksi minimum tensile strength.
2. Furnish flat sheets only, rolled sheets not permitted.

2.02 ACCESSORIES

A. Tie Wire:

1. Black, soft-annealed 16-gauge wire.
2. Nylon-, epoxy-, or plastic-coated wire.

B. Bar Supports and Spacers:

1. Use precast concrete bar supports or all-plastic bar supports and side form spacers, unless noted otherwise. Do not use other types of supports or spacers.
2. Bar supports shall have sufficient strength and stiffness to carry loads without failure, displacement, or significant deformation. Space bar supports so minimum concrete cover is maintained for reinforcing between supports.
3. Use only precast concrete bar supports where concrete surfaces are exposed to weather, earth, water, chloride intrusion, or corrosive chemicals. Bar supports shall be nonconductive and have geometry and bond characteristics that deter movement of moisture from the surface to the reinforcement.
4. Precast concrete supports shall have same minimum strength and shall be made from same materials as that of the concrete in which they are to be embedded. Precast concrete supports shall be cast and properly cured for at least 7 days before use and shall have a wire or other device cast into each block for the purpose of attaching them securely to steel reinforcement.
5. In Beams, Columns, Walls, and Slabs Exposed to View after Form Removal: Use small precast concrete blocks made of same color as concrete in which they are embedded.
6. Design and fabricate special bar supports for top reinforcing bars in slabs where standard bar supports do not possess necessary geometry, strength, or stiffness.

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7. Plastic Bar Supports: Manufactured by Aztec Concrete Accessories, Bloomington, CA.
8. Precast Concrete Supports:
    a. Total bond precast, high-performance concrete bar supports as supplied by:
        1) Con Sys Inc., Pinawa, MB, Canada.
        2) Dayton Superior, Miamisburg, OH, Dobies.

2.03 FABRICATION

A. Follow CRSI Manual of Standard Practice.

B. Bend bars cold.

PART 3 EXECUTION

3.01 PREPARATION

A. Notify Engineer when reinforcing is ready for inspection and allow sufficient time for inspection prior to placing concrete.

B. Clean reinforcing bars of loose mill scale, oil, earth, and other contaminants.

3.02 INSTALLATION

A. Bundle or space bars, instead of field bending where construction access through reinforcing is necessary.

B. Spacing and Positioning: Conform to ACI 318.

C. Location Tolerances: In accordance with CRSI publication, “Placing Reinforcing Bars”.

D. Splicing:

1. Follow ACI 318.
2. Use lap splices, unless otherwise shown or permitted in writing by Engineer.
3. Welded Splices: Not permitted.
4. Stagger splices in adjacent bars where indicated.

E. Mechanical Splices and Connections:

1. Use only in areas specifically approved in writing by Engineer.
2. Install threaded rods as recommended by manufacturer with threads totally engaged into coupling sleeve and in accordance with ICC Evaluation Services Report or equivalent code agency report.

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3. For metal sleeve splice, follow manufacturer's installation recommendations.
4. Maintain minimum edge distance and concrete cover.

F. Tying Reinforcing Bars:

1. Tie every other intersection on mats made up of Nos. 3, 4, 5, and 6 bars to hold them firmly at required spacing.
2. Bend tie wire away from concrete surface to provide clearance of 1 inch from surface of concrete to tie wire.

G. Reinforcement Around Openings: On each side and above and below pipe or opening, place an equivalent area of steel bars to replace steel bars cut for opening. Extend steel reinforcing a standard lap length beyond opening at each end.

H. Straightening and Rebending: Field bending of steel reinforcement bars is not permitted.

I. Unless permitted by Engineer, do not cut reinforcing bars in field.

3.03 WELDED WIRE FABRIC INSTALLATION

A. Use only where specifically shown.

B. Extend fabric to within 2 inches of edges of slab and lap splices at least 1-1/2 courses of fabric or minimum 8 inches.

C. Tie laps and splices securely at ends and at least every 24 inches with tie wire.

D. Place welded wire fabric on concrete blocks and rigidly support equal to that provided for reinforced bars. Do not use broken concrete, brick, or stone.

E. Follow ACI 318 and WRI WWR-500.

F. Do not use fabric that has been rolled. Install flat sheets only.

3.04 FIELD QUALITY ASSURANCE AND QUALITY CONTROL

A. Owner-Furnished Quality Assurance, in accordance with IBC Chapter 17 requirements, is provided in the Statement of Special Inspections Plan on Drawings. Contractor responsibilities and related information are included in Section 01 45 33, Special Inspection, Observation, and Testing.

B. Contractor-Furnished Quality Control: Inspection and testing as required in Section 01 45 16.13, Contractor Quality Control.

END OF SECTION

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SECTION 03 24 00
FIBROUS REINFORCING

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   a. C78, Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading).
   b. C1116, Standard Specification for Fiber-Reinforced Concrete and Shotcrete.
   c. E119, Standard Test Methods for Fire Tests of Building Construction and Materials.

1.02 DEFINITIONS

A. Aspect Ratio: The ratio of length to diameter of the fiber.

B. Fibrillated Fibers: Fibers in bundles that, when added to concrete during mixing, separate into uniformly distributed angular fibrils (fiber strands) which act as secondary concrete reinforcement.

C. Macro-Fibers: Longer length, higher volume, typically 0.4 percent to 0.7 percent by volume fiber, sometimes referred to as structural fibers.

D. Micro-Fibers: Shorter length, low dose, typically 0.1 percent by volume fibers designed to control plastic shrinkage cracking.

E. Monofilament Fiber: Single filament fiber.

1.03 SYSTEM DESCRIPTION

A. Performance Requirements:

1. Minimum residual strength index of 50 psi.
2. 2-hour fire resistance rating when tested under ASTM E119 on Series 700, Series 800, and Series 900 composite metal deck assemblies.
3. **[A: .]**

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1.04 SUBMITTALS

A. Action Submittals:

1. Product data for fibrillated fibers.
2. **[A: Fiber reinforced concrete mix design.]**
3. **[B: .]**

B. Informational Submittals:

1. Manufacturer's written instructions for mixing and batching of fibrillated fibers.
2. **[A: Fiber manufacturer's Certificate of Compliance.]**
3. **[B: Manufacturer's written instruction for mixing and batching of fibrillated fibers with Microban "B".]**
4. **[C: Manufacturer's written test procedure for the residual strength index of fiber reinforced concrete.]**
5. **[D: Certificate of Compliance from concrete supplier as to type, brand name, and amount of fibers added to mix.]**
6. **[E: Fiber manufacturer's certification of registration as proof of ISO 9002 Fiber Manufacturing Facility Certification.]**

PART 2 PRODUCTS

2.01 MATERIALS

A. Micro-Fibers:

1. 100 percent virgin polypropylene self-fibrillating fibers.
2. Multidesign gradation.
3. Fibrillated bundles to allow uniform distributed angular fibrils (fiber strands) when mixed into concrete.
4. Specific Gravity: 0.91 minimum.
5. Reprocessed olefin materials are not allowed.
6. Type III fibers conforming to ASTM C1116, Part 4.1.3.
7. Fiber Length: 0.50 inch to 1.0 inch.
8. Manufacturers and Products:
   a. Euclid Chemical Company, Cleveland OH; Fiberstrand F.
   b. Propex Concrete Systems Corporation, Chattanooga, TN; Fibermesh 300.

B. Macro-Fibers:

1. Polypropylene/polyethylene monofilament.
2. Specific Gravity: 0.92.
3. Tensile Strength: 85 ksi minimum.
4. Type III fibers conforming to ASTM C1116.

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5. Aspect Ratio: 70 minimum.
6. Fiber Length: 1.50 inch to 2.0 inch.
7. Manufacturer:
    a. Euclid Chemical Company, Cleveland, OH; Tuf-Strand SF.
    b. W. R. Grace & Company, Cambridge, MA; Strux 90/40.
    c. Propex Concrete Systems Corporation, Chattanooga, TN; Fibermesh 650.

C. Concrete: Components shall conform to Section 03 30 00, Cast-in-Place Concrete.

2.02 CONCRETE MIX DESIGN AND CONCRETE MIXING

A. In accordance with Section 03 30 00, Cast-in-Place Concrete.

B. Add **[A: 1.5] [B:]** pounds minimum per cubic yard at the time concrete is batched.

C. Mix fibers into concrete in accordance with fiber manufacturer's instructions.

PART 3 EXECUTION

3.01 PLACING, PROTECTING, CURING, AND FINISHING

A. In accordance with Section 03 30 00, Cast-in-Place Concrete.

3.02 FIELD QUALITY CONTROL

A. Test as specified in Section 03 30 00, Cast-in-Place Concrete.

B. Test fiber reinforced concrete with a modified version of ASTM C78 test using the printed test procedure provided by Fibermesh.

C. Test minimum of two beam Samples prior to casting the concrete.

D. Test minimum of two additional beam Samples for each 25 cubic yards or any portion thereof used on the Project.

3.03 MANUFACTURER'S SERVICE

A. Provide the services of a technical representative to instruct the concrete supplier in proper batching and mixing of materials.

END OF SECTION

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SECTION 03 30 00
CAST-IN-PLACE CONCRETE

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards that may be referenced in this section:

1. American Concrete Institute (ACI):
   a. 117, Specification for Tolerances for Concrete Construction and Materials.
   b. 301, Specifications for Structural Concrete.
   c. 305.1, Specification for Hot Weather Concreting.
   d. 306.1, Standard Specification for Cold Weather Concreting.
   e. 350.1, Specification for Tightness Testing of Environmental Engineering Concrete Containment Structures.
   f. CP-1, Technical Workbook for ACI Certification of Concrete Field Testing Technician – Grade 1.
2. ASTM International (ASTM):
   a. C31/C31M, Standard Practice for Making and Curing Concrete Test Specimens in the Field.
   b. C33/C33M, Standard Specification for Concrete Aggregates.
   c. C39/C39M, Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
   d. C94/C94M, Standard Specification for Ready-Mixed Concrete.
   e. C109/C109M, Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50-mm] Cube Specimens).
   f. C143/C143M, Standard Test Method for Slump of Hydraulic-Cement Concrete.
   g. C150/C150M, Standard Specification for Portland Cement.
   h. C157/C157M, Standard Test Method for Length Change of Hardened Hydraulic-Cement Mortar and Concrete.
   i. C227, Standard Test Method for Potential Alkali Reactivity of Cement-Aggregate Combinations (Mortar-Bar Method).
   j. C231/C231M, Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method.
   k. C260/C260M, Standard Specification for Air-Entraining Admixtures for Concrete.
   l. C494/C494M, Standard Specification for Chemical Admixtures for Concrete.
   m. C595/C595M, Standard Specification for Blended Hydraulic Cements.

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n. C618, Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
o. C881/C881M, Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete.
p. C979/C979M, Standard Specification for Pigments for Integrally Colored Concrete.
q. C989, Standard Specification for Slag Cement for Use in Concrete and Mortars.
r. C1012/C1012M, Standard Test Method for Length Change of Hydraulic-Cement Mortars Exposed to a Sulfate Solution.
s. C1017/C1017M, Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete.
t. C1074, Standard Practice for Estimating Concrete Strength by the Maturity Method.
u. C1077, Standard Practice for Agencies Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Testing Agency Evaluation.
v. C1218/C1218M, Standard Test Method for Water-Soluble Chloride in Mortar and Concrete.
w. C1240, Standard Specification for Silica Fume Used in Cementitious Mixtures.
x. C1260, Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method).
y. C1293, Standard Test Method for Determination of Length Change of Concrete Due to Alkali-Silica Reaction.
z. C1567, Standard Test Method for Determining the Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method).
aa. C1582/C1582M, Standard Specification for Admixtures to Inhibit Chloride-Induced Corrosion of Reinforcing Steel in Concrete.
bb. C1602/C1602M, Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete.
cc. D4580, Standard Practice for Measuring Delaminations in Concrete Bridge Decks by Sounding.
dd. E329, Standard Specification for Agencies Engaged in Construction Inspection, Special Inspection, or Testing Materials Used in Construction.
ee. E1155, Standard Test Method for Determining F_F Floor Flatness and F_L Floor Levelness Numbers.

3. National Ready Mixed Concrete Association (NRMCA).

1.02 DEFINITIONS

A. Basin Train: Series of interconnected basins that operate as a unit with same water level.

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B. Cold Weather: When ambient temperature is below 40 degrees F or is approaching 40 degrees F and falling.

C. Contractor's Licensed Design Engineer: Individual representing Contractor who is licensed to practice engineering as defined by statutory requirements of professional licensing laws in state or jurisdiction in which Project is to be constructed.

D. Defective Area: Surface defects that include honeycomb, rock pockets, indentations, and surface voids greater than 3/16-inch deep, surface voids greater than 3/4 inch in diameter, cracks in liquid containment structures and below grade habitable spaces that are 0.005-inch wide and wider, and cracks in other structures that are 0.010-inch wide and wider, spalls, chips, embedded debris, sand streaks, mortar leakage from form joints, deviations in formed surface that exceed specified tolerances and include but are not limited to fins, form pop-outs, and other projections. At exposed concrete, defective areas also include texture irregularities, stains, and other color variations that cannot be removed by cleaning.

E. Exposed Concrete: Concrete surface that can be seen inside or outside of structure regardless of whether concrete is above water, dry at all times, or can be seen when structure is drained.

F. Hot Weather: As defined in ACI 305.1.

G. Hydraulic Structure: Liquid containment structure.

H. New Concrete: Less than 60 days old.

I. Slurry Mixture: Mixture of sand, 3/8-inch maximum nominal aggregate size, cement, and water for wall construction joints with waterstop.

1.03 SUBMITTALS

A. Action Submittals:

1. Mix Designs:
   a. Contain proportions of materials and admixtures to be used on Project, signed by mix designer.
   b. Documentation of average strength for each proposed mix design in accordance with ACI 301.
   c. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements, for the following:
      1) Portland cement.
      2) Fly ash.

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3) Aggregates, including specified class designation for coarse aggregate.
4) Admixtures.
5) Concrete producer has verified compatibility of constituent materials in design mix.

d. Test Reports:
1) Cement: Chemical analysis report.
2) Supplementary Cementitious Materials: Chemical analysis report and report of other specified test analyses.
3) Water-Soluble Chloride-Ion Content in Hardened Concrete: Unless otherwise permitted, in accordance with ASTM C1218/C1218M at an age between 28 days and 42 days.
4) Shrinkage Test Results: In accordance with ASTM C157/C157M as modified herein.

e. Aggregates:
1) Coarse Aggregate Gradation: List gradings and percent passing through each sieve.
2) Fine Aggregate Gradation: List gradings and percent passing through each sieve.
3) Percent of fine aggregate weight to total aggregate weight.
4) Deleterious substances in fine aggregate per ASTM C33/C33M, Table 2.
5) Deleterious substances in coarse aggregate per ASTM C33/C33M, Table 4.
6) Test Reports:
a) Alkali Aggregate Reactivity: Aggregate shall be classified as nonpotentially reactive in accordance with Article Concrete Mix Design. Include documentation of test results per applicable standards.

f. Admixtures: Manufacturer's catalog cut sheets and product data sheets for each admixture used in proposed mix designs.

2. Product Data: Specified ancillary materials.
3. Detailed plan for curing and protection of concrete placed and cured in cold weather. Details shall include, but not be limited to, the following:
a. Procedures for protecting subgrade from frost and accumulation of ice or snow on reinforcement, other metallic embeds, and forms prior to placement.
b. Procedures for measuring and recording temperatures of reinforcement and other embedded items prior to concrete placement.
c. Methods for temperature protection during placement.
d. Types of covering, insulation, housing, or heating to be provided.
e. Curing methods to be used during and following protection period.

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f. Use of strength accelerating admixtures.
g. Methods for verification of in-place strength.
h. Procedures for measuring and recording concrete temperatures.
i. Procedures for preventing drying during dry, windy conditions.

4. Detailed plan for hot weather placements including curing and protection for concrete placed in ambient temperatures over 80 degrees F. Plan shall include, but not be limited to, the following:
   a. Procedures for measuring, and recording temperatures of reinforcement and other embedded items prior to concrete placement.
   b. Use of retarding admixture.
   c. Methods for controlling temperature of reinforcement and other embedded items and concrete materials before and during placement.
   d. Types of shading and wind protection to be provided.
   e. Curing methods, including use of evaporation retardant.
   f. Procedures for measuring and recording concrete temperatures.
   g. Procedures for preventing drying during dry, windy conditions.

B. Informational Submittals:

1. Preinstallation Conference minutes.
2. Manufacturer's application instructions for bonding agent and bond breaker.
3. Manufacturer's Certificate of Compliance to specified standards:
   a. Bonding agent.
   b. Bond breaker.
4. Statement of Qualification:
   a. Batch Plant: Certification as specified herein.
   b. Mix designer.
   c. Installer.
   d. Testing agency.
5. Field test reports.
6. Tightness test results.
7. Concrete Delivery Tickets:
   a. For each batch of concrete before unloading at Site.
   b. In accordance with ASTM C94/C94M, including requirements 14.2.1. through 14.2.10.
   c. Indicate amount of mixing water withheld and maximum amount that may be permitted to be added at Site.

1.04 QUALITY ASSURANCE

A. Concrete construction shall conform to requirements of ACI 117 and ACI 301, except as modified herein.

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B. Qualifications:

1. Batch Plant: NRMCA Program for Certification of Ready-Mixed Concrete Production Facilities or approved equivalent program.
2. Mix Designer: Person responsible for developing concrete mixture proportions certified as NRMCA Concrete Technologist Level 2 or DOT certified mix designer in jurisdiction of the Work. Requirement may be waived if individual is Contractor's Licensed Design Engineer.
3. Flatwork Finisher: Unless otherwise permitted, at least one person on finishing crew shall be certified as an ACI Flatwork Finisher.
4. Testing Agency: Unless otherwise permitted, an independent agency, acceptable to authorities having jurisdiction, qualified according to ASTM C1077 and ASTM E329 for testing indicated.
    a. Where field testing is required of Contractor, personnel conducting field tests shall be qualified as ACI Concrete Field Testing Technician, Grade 1, according to ACI CP-1 or an equivalent certification program.
    b. Personnel performing laboratory tests shall be ACI-certified Concrete Strength Testing Technician and Concrete Laboratory Testing Technician - Grade I. Testing Agency laboratory supervisor shall be an ACI-certified Concrete Laboratory Testing Technician - Grade II.

C. Preinstallation Conference:

1. Required Meeting Attendees:
    a. Contractor, including pumping, placing and finishing, and curing subcontractors.
    b. Ready-mix producer.
    c. Admixture representative.
    d. Testing and sampling personnel.
    e. Engineer who authored Statement of Special Inspection Plan or Engineer's designee.
2. Schedule and conduct prior to incorporation of respective products into Project. Notify Engineer of location and time.
3. Agenda shall include:
    a. Admixture types, dosage, performance, and redosing at Site.
    b. Mix designs, test of mixes, and Submittals.
    c. Placement methods, techniques, equipment, consolidation, and form pressures.
    d. Slump and placement time to maintain slump.
    e. Finish, curing, and water retention.
    f. Protection procedures for weather conditions.
    g. Other specified requirements requiring coordination.
4. Conference minutes as specified in Section 01 31 19, Project Meetings.

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PART 2 PRODUCTS

2.01 MATERIALS

A. Cementitious Materials:

1. Cement:
   a. Portland Cement: Unless otherwise specified, conform to requirements of ASTM C150/C150M.
   b. Blended Hydraulic Cement:
      1) Unless otherwise specified, conform to requirements of ASTM C595/C595M.
      2) Portland cement used in blended hydraulic cement, conform to requirements of ASTM C150/C150M.
   c. Furnish from one source.
2. Supplementary Cementitious Materials (SCM):
   a. Fly Ash (Pozzolan): Class F fly ash in accordance with ASTM C618, except as modified herein:
      1) Shall not be produced from process that has utilized hazardous or potentially hazardous materials.
      2) ASTM C618, Table 1, Loss on Ignition: Unless permitted otherwise, maximum 3 percent.

B. Aggregates: Furnish from one source for each aggregate type used in a mix design.

1. Normal-Weight Aggregates:
   a. In accordance with ASTM C33/C33M, except as modified herein.
      1) Class Designation: 4S unless otherwise specified.
   b. Free of materials and aggregate types causing popouts, discoloration, staining, or other defects on surface of concrete.
   c. Alkali Silica Reactivity: See Article Concrete Mix Design.
2. Fine Aggregates:
   a. Clean, sharp, natural sand.
   b. ASTM C33/C33M.
   c. Limit deleterious substances in accordance with ASTM C33/C33M, Table 2 and as follows:
      1) Limit material finer than 75-µm (No. 200) sieve to 3 percent mass of total sample.
      2) Limit coal and lignite to 0.5 percent.
3. Coarse Aggregate:
   a. Natural gravels, combination of gravels and crushed gravels, crushed stone, or combination of these materials containing no more than 15 percent flat or elongated particles (long dimension more than five times the short dimension).

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b. Limit deleterious substances in accordance with ASTM C33/C33M, Table 4 for specified class designation.

C. Admixtures: Unless otherwise permitted, furnish from one manufacturer.

1. Characteristics:
   a. Compatible with other constituents in mix.
   b. Contain at most, only trace amount chlorides in solution.
   c. Furnish type of admixture as recommended by manufacturer for anticipated temperature ranges.
2. Air-Entraining Admixture: ASTM C260/C260M.
3. Water-Reducing Admixture: ASTM C494/C494M, Type A or Type D.
   a. Manufacturers and Products:
      1) BASF Admixtures Inc., Shakopee, MN; MasterPozzolith Series or MasterPolyHeed Series.
      2) Euclid Chemical Co., Cleveland, OH; Eucon Series.
      3) W. R. Grace & Co., Cambridge, MA; Daracem Series or Mira Series.
4. Retarding Admixture: ASTM C 494/C 494M, Type B.
5. Accelerating Admixture: ASTM C 494/C 494M, Type C.
6. High-Range, Water-Reducing Admixture: ASTM C494/C494M, Type F or Type G.
   a. Manufacturers and Products:
      1) BASF Admixtures Inc., Shakopee, MN; MasterGlenium Series, or MasterRheobuild 1000.
      2) Euclid Chemical Co., Cleveland, OH; Eucon Series or Plastol Series.
      3) W. R. Grace & Co., Cambridge, MA; ADVA Series, Daracem Series, or EXP 950.
7. Plasticizing Admixture: ASTM C1017/C1017M, Type I or Type II.
8. Corrosion Inhibiting Admixtures: ASTM C1582/C1582M.
9. Shrinkage Reducing Admixture:
   a. Manufacturers and Products:
      1) BASF Admixtures Inc., Shakopee, MN; Masterlife SRA 20.
      2) Euclid Chemical Co., Cleveland, OH; Eucon SRA Series.
      3) W. R. Grace & Co., Cambridge, MA; Eclipse Series.
10. Do not use calcium chloride as an admixture.

D. Water and Ice: Mixing water for concrete and water used to make ice shall be potable water, unless alternative sources of water are permitted.

1. Water from alternative sources shall comply with requirements of ASTM C1602/C1602M, and concentration of chemicals in combined mixing water shall be less than:
   a. Chloride Content: 500 ppm.
   b. Sulfate Content as SO_4: 3,000 ppm.

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c. Alkalis as (Na_2O + 0.658 K_2O): 600 ppm.
d. Total Solids by Mass: Less than 50,000 ppm.

2.02 ANCILLARY MATERIALS

A. Bonding Agent: Unless otherwise specified, in accordance with the following:

1. ASTM C881/C881M, Type V.
2. Two-component, moisture insensitive, 100 percent solids epoxy.
3. Consult manufacturer for surface finish, pot life, set time, vertical or horizontal application, and forming restrictions.
4. Manufacturers and Products:
   a. BASF Building Systems Inc., Shakopee, MN; MasterEmaco ADH 326.
   b. Euclid Chemical Co., Cleveland, OH; Euco # 452 Epoxy System LV.
   c. Prime Resins, Conyers, GA; Prime Bond 3000 to 3900 Series.
   d. Sika Chemical Corp., Lyndhurst, NJ; Sikadur 32 Hi-Mod.

B. Bond Breaker:

1. Nonstaining type, providing positive bond prevention.
2. Manufacturers and Products:
   a. Dayton Superior Corporation, Kansas City, KS; Sure Lift J6WB.
   b. Nox-Crete Products Group, Omaha, NE; Silcoseal Select.

C. Repair Material:

1. In accordance with requirements of Section 03 01 32, Repair of Vertical and Overhead Concrete Surfaces.
2. In accordance with requirements of Section 03 01 33, Repair of Horizontal Concrete Surfaces.

D. Crack Repair: In accordance with requirements of Section 03 64 23, Crack Repair Epoxy Injection Grouting.

2.03 CONCRETE MIX DESIGN

A. General:

1. See Supplement at the end of this section for mix design requirements for each class of concrete used on Project.
2. Prepare design mixtures for each type and strength of concrete, selecting and proportioning ingredients in accordance with requirements of ACI 301, unless otherwise specified.
3. Selection of constituent materials and products in mix design are optional, unless specified otherwise.

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4. Unless otherwise permitted, use water-reducing admixture or water-reducing admixture and high-range, water-reducing admixture, or plasticizing admixture in pumped concrete, in concrete with a water-cementitious materials ratio below 0.50, and in concrete that is part of a liquid-containment structure.
5. Unless otherwise permitted, use water-reducing admixture and high-range, water-reducing admixture, or plasticizing admixture in columns, piers, pilasters, and walls.
6. Use water-reducing admixture or high-range, water-reducing admixture, or plasticizing admixture to achieve fresh properties that facilitate handling, placing, and consolidating of concrete, and specified hardened properties.
7. Use water-reducing and retarding admixture when anticipated high temperatures, low humidity, or other adverse placement conditions can adversely affect fresh properties of concrete.
8. Unless otherwise specified, desired fresh properties of concrete shall be determined by Contractor, and coordinated with concrete producer. Fresh properties of concrete shall remain stable to satisfaction of Contractor, for duration of placement and consolidation, and shall remain in conformance with requirements of Contract Documents.
9. Contractor is encouraged to consider using environmentally sustainable concrete mix design technologies such as use of supplementary cementitious materials and aggregate packing.

B. Potential alkali-aggregate reactivity of concrete:

1. Do not use aggregates known to be susceptible to alkali-carbonate reaction (ACR).
2. Aggregates shall have been tested to determine potential alkali-aggregate reactivity in concrete in accordance with ASTM C1260 or ASTM C1567.
    a. Aggregates that indicate expansion greater than 0.10 percent at 16 days after casting shall not be used unless they have been shown to be nondeleteriously reactive in accordance with ASTM C227 or ASTM C1293, with less than 0.04 percent expansion at 1 year for cement-aggregate combinations or less than 0.04 percent expansion at 2 years for combinations with pozzolan or slag.
    b. Alkali content of cement used in proposed concrete mixture shall not be greater than alkali content of cement used in test for potential alkali-aggregate reactivity.
    c. Use low-alkali cement or incorporate pozzolans into concrete mixture as necessary to satisfy testing for potential alkali reactivity.

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C. Proportions:

1. Design mix to meet aesthetic, durability, and strength requirements.
2. Where fly ash is included in mix, fly ash content shall be a minimum of 15 percent of weight of total cementitious materials.

D. Concrete Shrinkage Limits: Where shrinkage limits are specified, design mix for following shrinkage limits and test in accordance with ASTM C157/C157M, with the following modifications:

1. Prisms shall be moist cured for 7 days prior to 28-day drying period.
2. Comparator reading at end of 7-day moist cure shall be used as initial length in length change calculation.
3. Reported results shall be average of three prisms.
4. If shrinkage of a specimen departs from average of that test age by more than 0.004 percent, disregard results obtained from that specimen.
5. Unless otherwise specified, results at end of 28-day drying period shall not exceed 0.040 percent if 3-inch prisms are used, or exceed 0.038 percent if 4-inch prisms are used. Aggregate will be rejected if test values exceed these limits.

E. Slump Range at Site:

1. Prior to submitting mix design, consult with concrete producer and select a target slump value at point of delivery, for each application of each design mix. Unless otherwise permitted, target slump value will then be enforced for duration of Project.
2. Design mixes that include a high-range, water-reducing or a plasticizing admixture shall have a minimum slump of 2 inches prior to addition of admixture. Unless otherwise permitted, slump shall be 8 inches maximum at point of delivery, for concrete with a high-range, water-reducing admixture.
3. Slump tolerance shall meet requirements of ACI 117.

F. Combined Aggregate Gradation:

1. Combined Gradation Limits: Limits shown are for coarse aggregates and fine aggregates mixed together (combined). Select one of the gradations shown in the following table:

	Combined Gradation Percentage Passing		
Sieve Sizes	**1-1/2" Max.**	**1" Max.**	**3/4" Max.**
2"	100	-	-
1-1/2"	95 - 100	100	-

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Sieve Sizes	Combined Gradation Percentage Passing		
	1-1/2" Max.	**1" Max.**	**3/4" Max.**
1"	65 - 85	90 - 100	100
3/4"	55 - 75	70 - 90	92 - 100
1/2"	-	-	68 - 86
3/8"	40 - 55	45 - 65	57 - 74
No. 4	30 - 45	31 - 47	38 - 57
No. 8	23 - 38	23 - 40	28 - 46
No. 16	16 - 30	17 - 35	20 - 36
No. 30	10 - 20	10 - 23	14 - 25
No. 50	4 - 10	2 - 10	5 - 14
No. 100	0 - 3	0 - 3	0 - 5
No. 200	0 - 2	0 - 2	0 - 2

2.04 CONCRETE MIXING

A. General: In accordance with ACI 301, except as modified herein.

B. Truck Mixers:

1. For every truck, test slump of samples taken per ASTM C94/C94M, paragraph 12.5.1.
2. Where specified slump is more than 4 inches, and if slump tests differ by more than 2 inches, discontinue use of truck mixer, unless causing condition is corrected and satisfactory performance is verified by additional slump tests.

2.05 SOURCE QUALITY CONTROL

A. Source Quality Control Inspection: Engineer shall have access to and have right to inspect batch plants, cement mills, and supply facilities of suppliers, manufacturers, and Subcontractors, providing products included in this section.

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PART 3 EXECUTION

3.01 PLACING CONCRETE

A. Preparation: Meet requirements ACI 301, except as modified herein.

B. Inspection: Notify Engineer and Special Inspector at least 1 full working day in advance before starting to place concrete.

C. Placement into Formwork:

1. Reinforcement: Secure in position before placing concrete.
2. Place concrete as soon as possible after leaving mixer, without segregation or loss of ingredients, without splashing forms or steel above, and in layers not over 1.5 feet deep, except for slabs which shall be placed full depth. Place and consolidate successive layers prior to initial set of first layer to prevent cold joints.
3. Placement frequency shall be such that lift lines will not be visible in exposed concrete finishes.
4. Use placement devices, for example chutes, pouring spouts, and pumps as required to prevent segregation.
5. Vertical Free Fall Drop to Final Placement:
    a. Forms 8 Inches or Less Wide: 5 feet.
    b. Forms Wider than 8 Inches: 8 feet, except as specified.
6. For placements where drops are greater than specified, use placement device such that free fall below placement device conforms to required value.
    a. Limit free fall to prevent segregation caused by aggregates hitting steel reinforcement.
7. Do not use aluminum conveying devices.
8. Provide sufficient illumination in the interior of forms so concrete deposition is visible, permitting confirmation of consolidation quality.
9. Joints in Footings and Slabs:
    a. Ensure space beneath plastic waterstop completely fills with concrete.
    b. During concrete placement, make visual inspection of entire waterstop area.
    c. Limit concrete placement to elevation of waterstop in first pass, vibrate concrete under waterstop, lift waterstop to confirm full consolidation without voids, and place remaining concrete to full height of slab.
    d. Apply procedure to full length of waterstop.
10. Trowel and round off top exposed edges of walls with 1/4-inch radius steel edging tool.
11. Cure concrete as specified in Section 03 39 00, Concrete Curing.

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D. Conveyor Belts and Chutes:

1. Design and arrange ends of chutes, hopper gates, and other points of concrete discharge throughout conveying, hoisting, and placing system for concrete to pass without becoming segregated.
2. Do not use chutes longer than 50 feet.
3. Minimum Slopes of Chutes: Angled to allow concrete to readily flow without segregation.
4. Conveyor Belts:
    a. Approved by Engineer.
    b. Wipe clean with device that does not allow mortar to adhere to belt.
    c. Cover conveyor belts and chutes.

E. Retempering: Not permitted for concrete where cement has partially hydrated.

F. Pumping of Concrete:

1. Provide standby pump, conveyor system, crane and concrete bucket, or other system onsite during pumping, for adequate redundancy to ensure completion of concrete placement without cold joints in case of primary placing equipment breakdown.
2. Minimum Pump Hose (Conduit) Diameter: 4 inches.
3. Replace pumping equipment and hoses (conduits) that are not functioning properly.

G. Maximum Size of Concrete Placements:

1. Limit size of each placement to allow for strength gain and volume change as a result of shrinkage.
2. Locate expansion, control, and contraction joints where shown on Drawings.
3. Construction Joints: Unless otherwise shown or permitted, locate construction joints as follows:
    a. Locate construction joints as shown on Drawings or where approved in joint location submittal required in Section 03 15 00, Concrete Joints and Accessories.
    b. Provide vertical construction joints in walls and slabs at maximum spacing of 40 feet, unless shown or approved otherwise.
    c. When vertical expansion, contraction, or control joint spacing does not exceed 60 feet, intermediate construction joints are not required.
    d. Uniformly space vertical construction joints within straight sections of walls and slabs, avoiding penetrations.

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4. Consider beams, girders, brackets, column capitals, and haunches as part of floor or roof system and place monolithically with floor or roof system.
5. Should placement sequence result in cold joint located below finished water surface, install waterstop in joint.

H. Minimum Time between Adjacent Placements:

1. Construction or Control Joints: 7 days unless otherwise specified.
2. Construction joint between top of footing or slab, and column or wall: As soon as can safely be done without damaging previously cast concrete or interrupting curing thereof, but not less than 24 hours.
3. Expansion or Contraction Joints: 1 day.
4. For columns and walls with a height in excess of 10 feet, wait at least 2 hours before depositing concrete in beams, girders, or slabs supported thereon.
5. For columns and walls 10 feet in height or less, wait at least 1 hour prior to depositing concrete in beams, girders, brackets, column capitals, or slabs supported thereon.

I. Consolidation and Visual Observation:

1. Consolidation Equipment and Methods: ACI 301.
2. Provide at least one standby vibrator in operable condition at Site prior to placing concrete.
3. Provide sufficient windows in forms or limit form height to allow for concrete placement through windows and for visual observation of concrete.
4. Vibrate concrete in vicinity of joints to obtain impervious concrete.

J. Hot Weather:

1. Prepare ingredients, mix, place, cure, and protect in accordance with ACI 301, ACI 305.1, and as follows:
   a. Maintain concrete temperature below 95 degrees F at time of placement, or furnish test data or other proof that admixtures and mix ingredients do not produce flash set plastic shrinkage, or cracking as a result of heat of hydration. Cool ingredients before mixing to maintain fresh concrete temperatures as specified or less.
   b. Provide for windbreaks, shading, fog spraying, sprinkling, ice, wet cover, or other means as necessary to maintain concrete at or below specified temperature.
2. Concrete Curing: As specified in Section 03 39 00, Concrete Curing.

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K. Cold Weather Placement:

1. Unless otherwise permitted, shall be in accordance with requirements of ACI 306.1 and as follows:
    a. Cold weather requirements shall apply when ambient temperature is below 40 degrees F or approaching 40 degrees F and falling.
    b. Do not place concrete over frozen earth or against surfaces with frost or ice present. Frozen earth shall be thawed to acceptance of Engineer.
    c. Unless otherwise permitted, do not place concrete in contact with surfaces less than 35 degrees F; requirement is applicable to all surfaces including reinforcement and other embedded items.
    d. Provide supplemental external heat as needed when other means of thermal protection are unable to maintain minimum surface temperature of concrete as specified in ACI 306.1.
    e. Maintain minimum surface temperature of concrete as specified in ACI 306.1 for no less than 3 days during cold weather conditions.
    f. Cure concrete as specified in Section 03 39 00, Concrete Curing.
        1) Protect concrete from freezing until end of curing period and until concrete has attained a compressive strength of 3,500 psi or design compressive strength if less than 3,500 psi.
2. Provide maximum and minimum temperature sensors placed on concrete surfaces spaced throughout Work to allow monitoring of concrete surface temperatures representative of Work. Unless otherwise permitted, record surface temperature of concrete at least once every 12 hours during specified curing period.
3. External Heating Units: Do not exhaust heater flue gases directly into enclosed area as it causes concrete carbonation as a result of concentrated carbon dioxide.
4. Maintain curing conditions as specified in Section 03 39 00, Concrete Curing.

3.02 CONCRETE BONDING

A. Construction Joints in New Concrete Members:

1. Prepare surface of construction joint as specified in Section 03 15 00, Concrete Joints and Accessories.
2. Horizontal Construction Joints Containing Waterstop in New Concrete Walls:
    a. Unless otherwise permitted, place slurry mixture 4-inch maximum thickness, 2-inch minimum thickness in horizontal construction joints containing waterstops.
    b. Use positive measuring device such as bucket or other device that will contain only enough slurry mixture for depositing in visually

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measurable area of wall to ensure that portion of form receives appropriate amount of slurry mixture to satisfy placement thickness requirements.

c. Do not deposit slurry mixture from pump hoses or large concrete buckets, unless specified placement thickness can be maintained and verified through inspection windows close to joint, or by other means.

d. Limit concrete placed immediately on top of slurry mixture to 12 inches thick. Thoroughly vibrate to mix concrete and slurry mixture together.

B. Construction Joints at Existing Concrete:

1. Thoroughly clean and mechanically roughen existing concrete surfaces to roughness profile of 1/4 inch.
2. Saturate surface with water for 24 hours prior to placing new concrete.

3.03 REPAIRING CONCRETE

A. General:

1. Inject cracks that leak with crack repair epoxy as specified in Section 03 64 23, Crack Repair Epoxy Injection Grouting.
2. Repair defective areas of concrete.
3. Repair horizontal concrete surfaces in accordance with Section 03 01 33, Repair of Horizontal Concrete Surfaces.
4. Repair vertical and overhead concrete surfaces in accordance with Section 03 01 32, Repair of Vertical and Overhead Concrete Surfaces.
5. Develop repair techniques with material manufacturer on surface that will not be visible in final construction prior to starting actual repair work and show how finish color will blend with adjacent surfaces. Obtain approval from Engineer.
6. Obtain quantities of repair material and manufacturer's detailed instructions for use to provide repair with finish to match adjacent surface or apply sufficient repair material adjacent to repair to blend finish appearance.
7. Repair of concrete shall provide structurally sound surface finish, uniform in appearance or upgrade finish by other means until acceptable to Engineer.

B. Tie Holes:

1. Unless otherwise specified, fill with specified repair material.
   a. Prepare substrate and mix, place, and cure repair material per manufacturer's written recommendations.

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C. Alternate Form Ties, Through-Bolts:

1. Mechanically roughen entire interior surface of through hole.
2. Apply bonding agent to roughened surface and drive elastic vinyl plug to half depth.
3. Dry pack entire hole from both sides of plug with nonshrink grout, as specified in Section 03 62 00, Nonshrink Grouting.
4. Use only enough water to dry pack grout.
5. Dry pack while bonding agent is still tacky.
6. If bonding agent has dried, remove bonding agent by mechanical means and reapply new coat of bonding agent.
7. Compact grout using steel hammer and steel tool to drive grout to high density.
8. Cure grout with water.

D. Exposed Metal Objects:

1. Remove metal objects not intended to be exposed in as-built condition of structure including wire, nails, and bolts, by chipping back concrete to depth of 1 inch and then cutting or removing metal object.
2. Repair area of chipped-out concrete as specified for defective areas.

E. Blockouts at Pipes or Other Penetrations: Where shown install in accordance with requirements of Drawings.

3.04 CONCRETE WALL FINISHES

A. Type W-1 (Ordinary Wall Finish):

1. Patch tie holes.
2. Knock off projections.
3. Repair defective areas.
4. Inject cracks in accordance with requirements of Section 03 64 23, Crack Repair Epoxy Injection Grouting.

B. Type W-2 (Smooth Wall Finish):

1. Patch tie holes.
2. Grind off fins and other projections.
3. Repair defective areas to provide smooth uniform appearance.
4. Inject cracks in accordance with requirements of Section 03 64 23, Crack Repair Epoxy Injection Grouting.

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C. Type W-5 (Finish for Painting):

1. In accordance with requirements for Type W-2 except as follows:
   a. Leave surface ready for painting as specified in Section 09 90 00, Painting and Coating.

3.05 CONCRETE SLAB FINISHES

A. General:

1. Use manual screeds, vibrating screeds, or roller compacting screeds to place concrete level and smooth.
2. Do not use “jitterbugs” or other special tools designed for purpose of forcing coarse aggregate away from surface and allowing layer of mortar, which will be weak and cause surface cracks or delamination, to accumulate.
3. Finish slab in accordance with specified slab finish.
4. Do not dust surfaces with dry materials nor add water to surfaces.
5. Cure concrete as specified in Section 03 39 00, Concrete Curing.

B. Type S-1 (Steel Troweled Finish):

1. Finish by screeding and floating with straightedges to bring surfaces to required finish elevation.
2. Wood float to true, even plane with no coarse aggregate visible.
3. Use sufficient pressure on wood floats to bring moisture to surface.
4. After surface moisture has disappeared, hand steel trowel concrete to produce smooth, smooth dense surface, free from trowel marks.
5. Provide light steel-troweled finish (two trowelings) at air-entrained slabs. Provide hard steel-troweled finish (ringing sound from the trowel) for nonair-entrained slabs.
6. Do not use dry cement or additional water during troweling, nor will excessive troweling be permitted.
7. Power Finishing:
   a. Approved power machine may be used in lieu of or in addition to hand finishing in accordance with directions of machine manufacturer.
   b. Do not use power machine when concrete has not attained necessary set to allow finishing without introducing high and low spots in slab.
   c. Do first steel troweling for slab S-1 finish by hand.

C. Type S-2 (Wood Float Finish):

1. Finish slab to receive fill and mortar setting bed by screeding with straightedges to bring surface to required finish plane.

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2. Wood float finish to compact and seal surface.
3. Remove laitance and leave surface clean.
4. Coordinate with other finish procedures.

D. Type S-3 (Underside Elevated Slab Finish): When forming is removed, grind off projections on underside of slab and repair defective areas, including small shallow air pockets where schedule of concrete finishes requires:

E. Type S-5 (Broomed Finish):

1. Finish as specified for Type S-1 floor finish, except use only a light-steel troweled finish, and then finish surface by drawing fine-hair broom lightly across surface.
2. Broom in same direction and parallel to expansion joints, or, in case of inclined slabs, perpendicular to slope, except for round roof slab, broom surface in radial direction.

F. Type S-6 (Sidewalk Finish):

1. Slope walks down 1/4 inch per foot away from structures, unless otherwise shown.
2. Strike off surface by means of strike board and float with wood or cork float to true plane, then flat steel trowel before brooming.
3. Broom surface at right angles to direction of traffic or as shown.
4. Lay out sidewalk surfaces in blocks, as shown or as directed by Engineer, with grooving tool.

G. [A: Type S-7 (for Clarifier or Float Thickener Slab): Wood float and screed with straight edges. Prepare surface for fiber reinforced grout topping as specified.]

H. Concrete Curbs:

1. Float top surface of curb smooth, and finish all discontinuous edges with steel edger.
2. After concrete has taken its initial set, remove front form and give exposed vertical surface an ordinary wall finish, Type W-1.

3.06 CONCRETE SLAB TOLERANCES

A. Slab Tolerances:

1. Exposed Slab Surfaces: Comprise of flat planes as required within tolerances specified.
2. Slab Finish Tolerances and Slope Tolerances: Crowns on floor surface not too high as to prevent 10-foot straightedge from resting on end

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blocks, nor low spots that allow block of twice the tolerance in thickness to pass under supported 10-foot straightedge.

3. Slab Type S-A: Steel gauge block 5/16 inch thick.
4. Slab Type S-B: Steel gauge block 1/8 inch thick.
5. Slab Type S-A and S-B: Finish Slab Elevation: Slope slabs to floor drain and gutter, and shall adequately drain regardless of tolerances.
6. Thickness: Maximum 1/4 inch minus or 1/2 inch plus from thickness shown. Where thickness tolerance will not affect slope, drainage, or slab elevation, thickness tolerance may exceed 1/2 inch plus.

B. Slab Elevation and Thickness:

1. Finish Slab Elevation: Slope slabs to floor drains and gutter. Slabs shall adequately drain regardless of tolerances.
2. Thickness: Maximum 1/4 inch minus or 1/2 inch plus from thickness shown. Where thickness tolerance will not affect slope, drainage, or slab elevation, thickness tolerance may exceed 1/2 inch plus.

3.07 BEAM AND COLUMN FINISHES

A. Type B-1: Match wall Type W-1.

B. Type B-2: Match wall Type W-2.

C. Type B-3:

1. Repair rock pockets.
2. Fill air voids.
3. Match wall Type W-5.

D. Type C-1: Match wall Type W-1.

E. Type C-2: Match wall Type W-2.

F. Type C-3:

1. Fill air pockets.
2. Match wall Type W-5.

3.08 BACKFILL AGAINST STRUCTURES

A. Do not backfill against walls until concrete has obtained specified 28-day compressive strength.

B. Refer to General Structural Notes on the Drawings for additional requirements, including elevated slab and diaphragm completion prior to backfill.

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C. Unless otherwise permitted, place backfill simultaneously on both sides of structure, where such fill is required, to prevent differential pressures.

3.09 CLEANING AND STERILIZING OF POTABLE WATER BASINS

A. Clean and sterilize structures for potable water as specified in Section 33 13 00, Disinfection of Water Utility Distribution Facilities.

3.10 FIELD QUALITY CONTROL

A. General:

1. Provide adequate facilities for safe storage and proper curing of concrete test specimens onsite for first 24 hours, and for additional time as may be required before transporting to test lab.
2. Unless otherwise specified, sample concrete for testing for making test specimens, from point of delivery.
3. When concrete is pumped, sample and test air content at point of delivery and at point of placement.
    a. For Each Concrete Mixture: Provided results of air content tests for first load of the day are within specified limits, testing need only be performed at point of delivery for subsequent loads of that concrete mixture except that testing should be performed at point of placement every 4 hours.
4. Evaluation will be in accordance with ACI 301 and Specifications.
5. Test specimens shall be made, cured, and tested in accordance with ASTM C31/C31M and ASTM C39/C39M.
6. Frequency of testing may be changed at discretion of Engineer.
7. Pumped Concrete: Take concrete samples for slump, ASTM C143/C143M, and test specimens, ASTM C31/C31M and ASTM C39/C39M, and shrinkage specimens (ASTM C157/C157M) at placement (discharge) end of line.
8. If measured air content at delivery is greater than specified limit, check test of air content will be performed immediately on a new sample from delivery unit. If check test fails, concrete has failed to meet requirements of Contract Documents. If measured air content is less than lower specified limit, adjustments will be permitted in accordance with ASTM C94/C94M, unless otherwise specified. If check test of adjusted mixture fails, concrete has failed to meet requirements of Contract Documents. Concrete that has failed to meet requirements of Contract Documents shall be rejected.

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B. Concrete Strength Test:

1. Unless otherwise specified, one specimen at age of 7 days for information, and two 6-inch diameter or when permitted three 4-inch diameter test specimens at age of 28 days for acceptance.
2. If result of 7-day concrete strength test is less than 50 percent of specified 28-day strength, extend period of moist curing specified in Section 03 39 00, Concrete Curing, by 7 additional days.
3. Provide a minimum of one spare test specimen per sample. Test spare cylinder as directed by Engineer.

C. Shrinkage Tests:

1. When required to conform to shrinkage limits, collect actual concrete materials being batched and before liquids have been added to mix.
2. Mix sampled material in a laboratory at proportions matching batched concrete.
3. Test shrinkage characteristics every 5,000 cubic yards of concrete used on job and every 3 months during construction when compression test cylinders are made.
4. Concrete Shrinkage Limits: Test in accordance with ASTM C157/C157M, with the following modifications:
    a. Prisms shall be moist cured for 7 days prior to 28-day drying period.
    b. Comparator reading at end of 7-day moist cure shall be used as initial length in length change calculation.
    c. Reported results shall be average of three prisms.
    d. If drying shrinkage of a specimen departs from average of that test age by more than 0.004 percent, disregard results obtained from that specimen.
    e. Results at end of 28-day drying period shall not exceed 0.040 percent if 3-inch prisms are used, or exceed 0.038 percent if 4-inch prisms are used.
    f. If 7-day or 14-day shrinkage tests results exceed shrinkage limits established by design mix testing, furnish additional 14 days of water curing beyond original curing period, for concrete surfaces of hydraulic structures represented by prisms. Modify concrete mix design to reduce shrinkage prior to casting additional concrete on Project.

D. High-Range, Water-Reducer (Superplasticizer) Admixture Segregation Test: Test each truck prior to use on Project.

1. Segregation Test Objective: Concrete with 4-inch to 8-inch slump shall stay together when slumped. Segregation is assumed to cause mortar to

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flow out of mix even though aggregate may stay piled enough to meet slump test.

2. Test Procedure: Make slump test and check for excessive slump and observe to see if mortar or moisture flows from slumped concrete.
3. Reject concrete if mortar or moisture separates and flows out of mix.

E. Cold Weather Placement Tests:

1. During cold weather concreting, cast cylinders for field curing as follows. Use method that will produce greater number of specimens:
   a. Six extra test cylinders from last 100 cubic yards of concrete.
   b. Minimum three specimens for each 2 hours of placing time or for each 100 cubic yards.
2. These specimens shall be in addition to those cast for lab testing.
3. Protect test cylinders from weather until they can be placed under same protection provided for concrete of structure that they represent.
4. Keep field test cylinders in same protective environment as parts of structure they represent to determine if specified strength has been obtained.
5. Test cylinders in accordance with applicable sections of ASTM C31/C31M and ASTM C39/C39M.
6. Use test results to determine specified strength gain prior to falsework removal or for prestressing.

F. Tolerances:

1. Walls: Measure and inspect walls for compliance with tolerances specified in Section 03 10 00, Concrete Forming and Accessories.
2. Slab Finish Tolerances and Slope Tolerances:
   a. Make floor flatness measurements day after floor is finished and before shoring is removed to eliminate effects of shrinkage, curing, and deflection.
   b. Support 10-foot long straightedge at each end with steel gauge blocks of thicknesses equal to specified tolerance.
   c. Compliance with designated limits in four of five consecutive measurements is satisfactory, unless defective conditions are observed.

G. Liquid Tightness Tests:

1. Purpose: To determine integrity and liquid-tightness of finished exterior and interior concrete surfaces of liquid containment structures.
2. Test the following structures for liquid-tightness:
   a. Finished Water Pump Station.
   b. Floc-Sed Basin.
   c. Concrete Filters in Process Facility.

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d. Containment Areas in Chemical Facility.
e. Decant Pump Station.

3. Water for initial tightness test will be provided by [H: Owner] [I: Contractor].

4. Water source will be:
   a. Provide means to transport water to structure to be tested.
   b. If additional tightness tests are required because of failure to meet criteria, provide water for subsequent tests.
5. After testing has been completed, dispose of test water in a manner approved by Owner.
6. Liquid-Tightness Test Requirement:
   a. Perform tightness tests in accordance with ACI 350.1 and as specified herein.
   b. Do not place backfill or install brick facing, grout topping slab, coatings, or other work that will cover concrete surfaces until tightness testing has been completed and approved.
   c. Measure evaporation, precipitation, and temperature as specified.
7. Measure water surface at two points 180 degrees apart when possible where attachments, such as ladders exist, at 24-hour intervals.
8. Acceptance Criteria:
   a. Volume loss shall not exceed 0.050 percent of contained liquid volume per 24-hour period, adjusted for evaporation, precipitation, and temperature.
   b. Acceptance that structure has passed tightness test shall be based on total volume loss at end of specified test period.
9. Repairs When Test Fails:
   a. Dewater structure; fill leaking cracks with crack repair epoxy as specified in Section 03 64 23, Crack Repair Epoxy Injection Grouting.
   b. Patch areas of damp spots previously recorded, and repeat water leakage test in its entirety until structure successfully passes test.

3.11 MANUFACTURER'S SERVICES

A. Provide representative at Site in accordance with Section 01 43 33, Manufacturers' Field Services, for installation assistance, inspection, and certification of proper installation for concrete ingredients, mix design, mixing, and placement.

   1. Concrete Producer Representative:
      a. Observe how concrete mixes are performing.
      b. Be present during first placement of each type of concrete mix.
      c. Assist with concrete mix design, performance, placement, weather problems, and problems as may occur with concrete mix throughout Project, including instructions for redosing.

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d. Establish control limits on concrete mix designs.
e. Provide equipment for control of concrete redosing for air entrainment or high-range, water-reducing admixture, superplasticizers, at Site to maintain proper slump and air content if needed.

2. Admixture Manufacturer's Representative: Available for consultations as required to ensure proper installation and performance of specified products.
3. Bonding Agent Manufacturer's Representative: Available for consultations as required to ensure proper installation and performance of specified products.

3.12 PROTECTION OF INSTALLED WORK

A. After curing as specified in Section 03 39 00, Concrete Curing, and after applying final floor finish, cover slabs with plywood or particle board or plastic sheeting or other material to keep floor clean and protect it from material and damage as a result of other construction work.

B. Repair areas damaged by construction, using specified repair materials and approved repair methods.

3.13 SCHEDULE OF CONCRETE FINISHES

A. Form Tolerances: As specified in Section 03 10 00, Concrete Forming and Accessories.

B. Special Floor Finishes: As specified in Section 03 35 00, Concrete Finishing.

C. Provide concrete finishes as scheduled:

Area	Type of Finish	Required Form Tolerances
Exterior Wall Surfaces		
Abovegrade/exposed (above point 6" below finish grade)	W-2	W-B
Abovegrade/covered with brick veneer or other finish material	W-1	W-A
Backfilled/waterproofed (below point 6" below finish grade)	W-1	W-A
Backfilled/not waterproofed (below point 6" below final grade)	W-1	W-A

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Area	Type of Finish	Required Form Tolerances
Interior Wall Surfaces		
Open top water-holding tanks and basins/not painted or coated	W-2	W-A
Covered water-holding tanks and basins/not painted or coated	W-1	W-A
Water-holding tanks, channels, and basins/painted or coated	W-5	W-A
Buildings, pipe galleries, and other dry areas/not painted or coated	W-2	W-A
Buildings, pipe galleries, and other dry areas/painted or coated	W-5	W-A
Exterior Slabs		
Roof slab/exposed	S-5	S-B
Roof slab/covered with roofing material	S-1	S-A
Water-holding tanks and basins/top of wall	S-5	S-B
Top of footing	S-2	S-A
Other water-holding tanks and basins	S-1	S-A
Stairs and landings	S-5	S-B
Sidewalks	S-6	S-B
Other exterior slabs	S-5	S-A
Interior Slabs		
Buildings, pipe galleries, and other dry areas	S-1	S-B
Slabs to receive mortar setting bed for tile	S-2	S-A
Slabs to receive resilient flooring or carpet	S-1	S-A
Hydraulic channels	S-1	S-A
Underside of elevated slabs	S-3	S-A
Beams and Columns		
Beams/coated	B-3	B-A
Beams/not coated	B-2	B-A

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Area	Type of Finish	Required Form Tolerances
Columns/coated	C-3	C-A
Columns/not coated	C-2	C-A

3.14 SUPPLEMENTS

A. Requirements of concrete mix designs following "End of Section," are a part of this Specification and supplement requirements of Part 1 through Part 3 of this section:

1. Concrete Mix Design, Class 4500F2S1W1C1.
2. Concrete Mix Design, Class SM00F2S1W1C1.
3. Concrete Mix Design, Class 4000F1S1W1C1.

END OF SECTION

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CONCRETE MIX DESIGN, CLASS 4500F2S1W1C1

A. Mix Locations: Hydraulic Structures and Foundations.

B. Exposure Categories and Classifications: F2S1W1C1 per ACI 318-14, 19.1.

C. Mix Properties:

1. Limit water to cementitious materials ratio (W/Cm) in mix design to maximum value of 0.45.
2. Minimum concrete compressive strength (f'c) shall be 4,500 psi at 28 days.
    a. Designed to conform to shrinkage limits.
    b. Air-entraining admixtures are prohibited in concrete mixtures and total air content shall not be greater than 3 percent, for the following:
        1) Slabs to receive a hard-troweled finish.
        2) Slabs to receive a dry shake floor hardener.
        3) Slabs to receive a topping placed monolithically as a two-course floor on top of plastic concrete.
    c. Unless otherwise specified, provide air content based on nominal maximum size of aggregate as follows:

Nominal Maximum Aggregate Size in. ‡	**Air Content (%)***
3/8	7.5
1/2	7.0
3/4	6.0
1	6.0
1-1/2	5.5
2§	5.0
3§	4.5

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Nominal Maximum Aggregate Size in. ‡	Air Content (%)*
‡See ASTM C33/C33M for tolerance on oversize for various nominal maximum size designations. *Tolerance of air content is +1-1/2 percent. §Air contents apply to total mixture. When testing concretes, however, aggregate particles larger than 1-1/2 inches are to be removed by sieving and air content will be measured on sieved fraction (tolerance on air content as delivered applies to this value). Air content of total mixture is computed from value measured on sieved fraction passing 1-1/2-inch sieve in accordance with ASTM C231/C231M.	

3. Provide cementitious materials in accordance with one of the following:
   a. ASTM C150/C150M Type II; inclusion of supplementary cementitious materials in design mix is optional.
   b. ASTM C150/C150M types other than Type II, plus supplementary cementitious materials in accordance with one of the following:
      1) Tricalcium Aluminate Content of Total Cementitious Materials: Maximum 8 percent by weight.
      2) Provide documentation of test results in accordance with ASTM C1012/C1012M, for combinations of cementitious materials providing sulfate resistance with expansion less than 0.10 percent at 6 months.
      3) ASTM C595/C595M Type IP or Type IS (less than 70), tested to comply with moderate sulfate resistance option (MS).
4. Limit water-soluble, chloride-ion content in hardened concrete to 0.30 percent, unless otherwise specified.
   a. Limits are stated in terms of chloride ions in percent by weight of cement.
   b. Unless otherwise permitted, provide documentation from concrete tested in accordance with ASTM C1218/C1218M at an age between 28 days and 42 days.

D. Refer to PART 1 through PART 3 of this section for additional requirements.

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CONCRETE MIX DESIGN, CLASS SM00F2S1W1C1

A. Mix Locations: Slurry mixture at horizontal construction joints with waterstop in wall.

B. Exposure Categories and Classifications: F2S1W1C1 per ACI 318-14, 19.1.

C. Mix Properties:

1. Limit water to cementitious materials ratio (W/Cm) in mix design to maximum value of 0.42.
2. Minimum concrete compressive strength (f'c) shall be same as concrete mix for wall.
3. Maximum Nominal Aggregate: 3/8 inch.
4. Unless otherwise specified, provide 7.5 percent air content.
    a. See ASTM C33/C33M for tolerance on oversize for various nominal maximum size designations.
    b. Tolerance of air content is plus or minus 1.5 percent.
5. Provide cementitious materials in accordance with one of the following:
    a. ASTM C150/C150M Type II; inclusion of supplementary cementitious materials in design mix is optional.
    b. ASTM C150/C150M types other than Type II, plus supplementary cementitious materials in accordance with one of the following:
        1) Tricalcium Aluminate Content of Total Cementitious Materials: Maximum 8 percent by weight.
        2) Provide documentation of test results in accordance with ASTM C1012/C1012M, for combinations of cementitious materials providing sulfate resistance with expansion less than 0.10 percent at 6 months.
    c. ASTM C595/C595M Type IP or Type IS (less than 70), tested to comply with moderate sulfate resistance option (MS).
        1) Provide documentation of test results in accordance with ASTM C1012/C1012M, for combinations of cementitious materials providing sulfate resistance with expansion less than 0.10 percent at 6 months.
6. Unless otherwise permitted, minimum cementitious materials content in mix design shall be 600 pounds per cubic yard for 3/8-inch nominal maximum size aggregate.
7. Limit water-soluble, chloride-ion content in hardened concrete to 0.10 percent, unless otherwise specified.
    a. Limits are stated in terms of chloride ions in percent by weight of cement.

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b. Unless otherwise permitted, provide documentation from concrete tested in accordance with ASTM C1218/C1218M at an age between 28 days and 42 days.

D. Refer to PART 1 through PART 3 of this section for additional requirements.

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CONCRETE MIX DESIGN, CLASS 4000F1S1W1C1

A. Mix Locations:

1. Electrical duct banks.
2. Pipe encasements that are not cast monolithically with concrete base mats or slabs.
3. Concrete Curbs and Sidewalks.

B. Exposure Categories and Classifications: F1S1W1C1 per ACI 318-14, 19.1.

C. Mix Properties:

1. Limit water to cementitious materials ratio (W/Cm) in mix design to maximum value of 0.45.
2. Minimum concrete compressive strength (f'c) shall be 4,000 psi at 28 days.
3. Air-entraining admixtures are prohibited in concrete mixtures and total air content shall not be greater than 3 percent, for the following:
   a. Slabs to receive hard-troweled finish.
   b. Slabs to receive dry shake floor hardener.
   c. Slabs to receive topping placed monolithically as two-course floor on top of plastic concrete.
4. Unless otherwise specified, provide air content based on nominal maximum size of aggregate as follows:

Nominal Maximum Aggregate Size in. ‡	**Air Content (%)***
3/8	6.0
1/2	5.5
3/4	5.0
1	4.5
1-1/2	4.5
2§	4.0
3§	3.5

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Nominal Maximum Aggregate Size in. ‡	Air Content (%)*
‡See ASTM C33/C33M for tolerance on oversize for various nominal maximum size designations. *Tolerance of air content is +1-1/2 percent. §Air contents apply to total mixture. When testing concretes, however, aggregate particles larger than 1-1/2 inches are to be removed by sieving and air content will be measured on the sieved fraction (tolerance on air content as delivered applies to this value). Air content of total mixture is computed from value measured on the sieved fraction passing the 1-1/2-inch sieve in accordance with ASTM C231/C231M.	

5. Provide cementitious materials in accordance with one of the following:
   a. ASTM C150/C150M Type II; inclusion of supplementary cementitious materials in design mix is optional.
   b. ASTM C150/C150M types other than Type II, plus supplementary cementitious materials in accordance with one of the following:
      1) Tricalcium Aluminate Content of Total Cementitious Materials: Maximum 8 percent by weight.
      2) Provide documentation of test results in accordance with ASTM C1012/C1012M, for combinations of cementitious materials providing sulfate resistance with expansion less than 0.10 percent at 6 months.
      3) ASTM C595/C595M Type IP or Type IS (less than 70), tested to comply with moderate sulfate resistance option (MS).
         a) Provide documentation of test results in accordance with ASTM C1012/C1012M, for combinations of cementitious materials providing sulfate resistance with expansion less than 0.10 percent at 6 months.
6. Limit water-soluble, chloride-ion content in hardened concrete to 0.30 percent, unless otherwise specified.
   a. Limits are stated in terms of chloride ions in percent by weight of cement.
   b. Unless otherwise permitted, provide documentation from concrete tested in accordance with ASTM C1218/C1218M at an age between 28 days and 42 days.

D. Refer to PART 1 through PART 3 of this section for additional requirements.

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SECTION 03 35 00
CONCRETE FINISHING

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM): C109, Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-In. or 50-Mm Cube Specimens).

1.02 SUBMITTALS

A. Action Submittals: Manufacturer's product data sheet(s).

B. Informational Submittals:

1. Agenda: Conference prior to slab placement.
2. Manufacturer's written procedures for slab preparation, product application, protection of finished surface, and post-application cleanup.
3. Product manufacturers representatives' names and phone numbers.
4. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements, for products to be furnished.
5. Manufacturer's Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers' Field Services.
6. Statement of Qualifications:
   a. Manufacturer's Product Service Record.
   b. Application personnel.
   c. Manufacturer's representative.
7. Manufacturer's installation instructions.
8. Manufacturer's written instructions for maintenance and repair of floor finishes installed.

1.03 QUALITY ASSURANCE

A. Qualifications:

1. Manufacturer's Product Service Record: Five previous projects at least 5 years old where product was used at representative coverage per square foot.
2. Floor Product Manufacturer: Manufacture components of floor material, except the epoxy, in own plant and under control of trained quality control manager.

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3. Application Personnel: Four previous projects of successful installation of specified materials or manufacturer's training.

B. Preinstallation Training: Manufacturer-approved training of application personnel and quality control inspectors for these floor finishes.

C. Conference Prior to Slab Placement:

1. Conducted by Contractor.
2. Agenda:
   a. Concrete mix design.
   b. Placing techniques.
   c. Finishing techniques.
   d. Floor hardener application procedures.
   e. Equipment required for these procedures.
3. Attendees:
   a. Contractor's superintendent.
   b. Subcontractor's representative involved in slab installation and finishing.
   c. Engineer.

D. Mockups: Install one 10-foot by 20-foot area for each type of finish floor to demonstrate that the material and methods produce a finished product acceptable to the Engineer.

1. Mockup will establish the standard of quality for floor finishes.
2. Use specified materials at a location designated by Engineer or Owner.
3. Notify Engineer 5 days in advance of commencement of mockup floor slab application and training.
4. Do not purchase floor materials until mockup slab installation has been accepted by the Engineer or Owner.

E. Color Samples: Minimum 2-inch by 2-inch Sample applications of floor finishes available.

PART 2 PRODUCTS

2.01 CLEAR LIQUID SEALER DUST PROOFER

A. Colorless, aqueous solution of zinc and magnesium fluorosilicate.

B. Each gallon of solution shall contain a minimum of 2 pounds of fluorosilicate compound.

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C. Manufacturers:

1. Master Builders Co., Cleveland, OH.
2. Sonneborn, Minneapolis, MN.
3. Euclid Chemical Co., Cleveland, OH.

2.02 DRY SHAKE HARDENERS

A. Mix: Surface hardener with metallic or natural aggregate, premixed and packaged at factory, delivered to Site ready to apply.

B. Natural Aggregate: Mixture of specially processed graded iron aggregate, selected portland cement, and necessary plasticizing agents formulated, processed, and packaged under stringent quality control at the manufacturer's factory.

1. Manufacturer and Product:
   a. **[A: Natural concrete gray, "Surflex" by Euclid Chemical Co. or "Mastercron" by Master Builders, Cleveland, OH.]**
   b. **[B: Colored and high reflective (white) "Surflex" by Euclid Chemical Co. or "Colorcron" by Master Builders, Cleveland, OH.]**
   c. **[C: Light reflective, (off-white) 50 percent light reflective "Surflex" by Euclid Chemical Co. or "Light Reflective Mastercron" by Master Builders, Cleveland, OH.]**

C. Metallic Aggregate: Metallic aggregate, cementitious binder, plasticizer, water-reducing admixtures, and other ingredients free from nonferrous particles, rust, and material intended to disguise rust.

1. Manufacturer and Product:
   a. **[A: Natural, concrete gray, and colored "Euco-Plate HD" by Euclid Chemical Co. or "Masterplate 200" by Master Builders, Cleveland, OH.]**
   b. **[B: Light reflective, (off-white) 50 percent to 57 percent reflectivity "Light Reflective Euco-Plate HD" or "Light Reflective Masterplate 200" by Master Builders, Cleveland, OH.]**
   c. **[C: "Light Reflective Nonoxidizing" (off-white) 50 percent to 57 percent reflectivity. Composed of specially processed nonoxidizing metallic aggregate and other proprietary ingredients with light reflective properties; "Lumiplate" by Master Builders, Cleveland, OH, or "Light Reflective Diamond Plate" by Euclid Chemical Co., Cleveland, OH.]**

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2.03 METALLIC AGGREGATE TOPPING

A. Topping Mix: Ready-to-use cement, iron aggregate, and plasticizing agent premixed and prepackaged, requiring only addition of water.

1. Manufacturer and Product: Euco-Top (screedable formulation) by Euclid Chemical Co. or ANVIL-TOP 300 by Master Builders, Cleveland, OH.

B. Topping Compressive Strength: 5,000 psi at 24 hours, 8,800 psi at 7 days, and 12,000 psi at 28 days.

C. Bonding Agent: 100 percent reactive, two-component, modified aliphatic/amine type epoxy resin bonding agent to dry base concrete; “Euco Epoxy No. 452MV” by Euclid Chemical Co. or ANVIL-BOND, manufactured by Master Builders, Cleveland, OH.

D. Membrane Curing Compound: “Super Floor Coat” by Euclid Chemical Co. or **[A: Masterkure] [B: Masterkure CR]** by Master Builders, Cleveland, OH.

E. Epoxy Joint Filler: The epoxy joint filler shall be a two-component, 100 percent solids compound, with a minimum shore D hardness of 50, “Euco 700” by Euclid Chemical Co., “MM-80” Metzger/McGuire.

PART 3 EXECUTION

3.01 CLEAR LIQUID SEALER DUST PROOFER APPLICATION

A. Before application, thoroughly cure floors to receive treatment for minimum 28 days, keep clean, unpainted, free from membrane curing compounds, and perfectly dry with all Work above them completed.

B. Apply hardener evenly to surface, using three coats, allowing 24 hours between coats.

1. First coat 1/3 strength, second coat 1/2 strength, and third coat 2/3 strength, mix with water.
2. Apply each coat so as to remain wet on surfaces for 15 minutes.
3. Apply approved treatment in accordance with manufacturer’s instructions.
4. After final coat is completed and dry, remove surplus hardener from surface by scrubbing and mopping with water.

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3.02 INSTALLATION OF DRY SHAKE HARDENERS

A. Application:

1. Application Rate: **[A: 2] [B:]** pounds per square foot or as recommended by manufacturer.
2. Penetration: Top 1/8-inch to 3/16-inch depth of floor slab.
3. Commence application immediately upon completion of floating surface area; bleed water shall not be present during and after application.
4. Distribute 2/3 of specified total quantity evenly on concrete surface to receive treatment by mechanical spreader; do not throw shake product.
5. Apply first to areas adjacent to forms, entry ways, columns, and walls where rapid moisture loss may occur.

B. Finishing:

1. Commence first mechanical float with finishing machines using float blades as soon as shake has absorbed moisture, as indicated by darkening of the surface area.
2. Float until moisture from base slab penetrates through first shake application.
3. Immediately distribute remaining 1/3 of total required shake by spreader and commence second mechanical float, as specified above.
4. Compact surface further by third mechanical float as time and setting characteristics of concrete allow.
5. Do not add water to surface area. In drying conditions, an evaporation retarder may be used to prevent plastic shrinkage cracking and rapid surface drying, subject to manufacturer’s recommendations and approval of Engineer.
6. Hand or mechanically trowel surface while stiffening progresses, as indicated by loss of sheen with blades relatively flat.
7. Run trowel blades as soon as possible to achieve representative finish obtained on mockup panel.
8. Avoid excessive trowel blade speed which may “burn” or darken floor surface resulting in loss of wear.
9. Remove marks and pinholes in final raised trowel operation.

C. Curing:

1. Cure treated floor surface to meet the recommendations of the dry shake hardener manufacturer. Apply curing compounds as soon as possible without marring the slab surface.
2. Commence slab protection when curing compound is dry.
   a. Cover slab with nonstaining kraft building paper to protect area from droppings.

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b. Maintain floor free of traffic and loads for at least 10 days after completion.

3.03 INSTALLATION OF METALLIC AGGREGATE TOPPING

A. Existing Concrete Surface Preparation:

1. Conduct vapor transmission test as specified, prior to application of bonding agent.
2. Prepare surface using Blastrac by Wheelabrator-Frye, Inc. or Porta-Shotblast by Nelco Manufacturing Corp. to depth that leaves dry, clean, surface free of unsound areas.
3. Apply bonding agent to dry base concrete slab just prior to placement of topping mix.

B. Armored Joint Treatment:

1. Cut down and remove concrete at joint lines to depth of 1/2 inch and taper back to surface level over 4-inch wide line for joints to receive armor.
2. Hand float cutdown area, working up sufficient paste at surface to ensure integral bond.
3. Mix metallic aggregate dry shake with sufficient water to produce a stiff mortar.
4. Place mortar into prepared joint; screed and float to top of form.
5. Use 2.25 pounds of metallic aggregate dry shake on each side of joint per linear foot.
6. Apply dry shake surface hardener as specified over designated floor area, including armored joint area after armored joint is in place.

C. Mixing: Mix in concrete mixer or ready-mix truck.

1. First add 3/4 of specified water quantity as recommended on product data sheet to mixer.
2. Proceed to add topping mix to water in a slow steady stream, followed by addition of remaining 1/4 of water.
3. Mix for 3 minutes or as recommended by manufacturer to provide 5-inch to 7-inch slump.
4. Mix shall be screedable and workable similar to concrete and shall not require compaction to attain specified strengths and density.
5. Perform slump test on each placement to ensure compliance with specified slump.
6. Place topping within 1 hour of water addition to mix and prior to loss of required slump.

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D. Placement of Aggregate:

1. Application Rate: **[A: 1] [B:]** inch thick with a minimum of 18 pounds of material per square foot per inch of thickness.
2. Place topping mixture by pump, bucket, or flow and screed level.
3. Finish with wooden bull float, one power floating, and one power troweling, or to meet the manufacturer's recommendations. Do not over finish.

E. Curing:

1. Commence curing immediately after completion of finish operation.
2. Wet cure by continuous water sprinkling or use wet burlap covered with polyethylene for minimum 2-day wet cure.
    a. Apply membrane curing compound specified as recommended by topping manufacturer.

3.04 TESTS AND INSPECTION

A. Vapor Transmission Test: Conduct test on new and existing concrete to show that no surface moisture exists prior to application of specified special floor treatment, as follows:

1. Place polyethylene plastic sheet, minimum 4 feet by 4 feet and sealed along four sides with duct tape to prevent moisture transmission by evaporation, over concrete floor area for 24 hours.
2. Indication of moisture transmission will be apparent by accumulation of moisture on enclosed surface of polyethylene plastic sheet.
3. Do not apply concrete bonding agent until test results indicate moisture is not being transmitted from concrete surface.

B. Strength Tests: Test metallic aggregate topping for compressive strength by making 2-inch by 2-inch cubes in accordance with ASTM C109.

C. Epoxy Joint Filler:

1. Allow 90 days after slab placement before filling joints.
2. Mix and install in accordance with manufacturer's instructions.
3. Fill contraction or construction joints in areas receiving armored joint treatment.

3.05 MANUFACTURER'S SERVICES

A. Provide manufacturer's representative at Site in accordance with Section 01 43 33, Manufacturers' Field Services, for installation assistance, inspection and certification of proper installation, and training of application personnel.

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1. Technical assistance with design and adjustment of concrete mixes to receive floor finishes and toppings.
2. Technical assistance to assure and certify application and installation of system being used.
3. Consultation, direction, and certification of mockup, for full-scale application of floor finishes, and at other times as needed.
4. Attendance at the conference prior to slab placement to finalize proper methods and procedures.

END OF SECTION

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SECTION 03 39 00
CONCRETE CURING

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Concrete Institute (ACI): 308.1, Specification for Curing Concrete.
2. ASTM International (ASTM):
   a. C309, Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete.
   b. C1315, Standard Specification for Liquid Membrane-Forming Compounds Having Special Properties for Curing and Sealing Concrete.
3. NSF International: 61, Drinking Water System Components – Health Effects.

1.02 SUBMITTALS

A. Action Submittals:

1. Manufacturers' data indicating compliance with the requirements specified herein for the following products:
   a. Exposed aggregate finish retardant on formed surface.
   b. Evaporation retardant.
   c. Curing compound.
   d. Penetrating water repellent sealer.
   e. Clear liquid densifier.
2. Curing methods proposed for each type of element such as slab, walls, beams, and columns in each facility.

B. Informational Submittals:

1. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements, for the following:
   a. Curing compound showing moisture retention requirements.
   b. Retardants for exposed aggregate finish.

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PART 2 PRODUCTS

2.01 MATERIALS

A. Curing Compound:

1. Water-based, high-solids content, nonyellowing, curing compound meeting requirements of ASTM C309 Type II, Class A.
2. Manufacturers and Products:
   a. Euclid Chemical Co., Cleveland, OH; Super Diamond Clear VOX.
   b. WR Meadows, Inc., Hampshire, IL; VOCOMP-30.
   c. Euclid Chemical Co., Cleveland, OH; EucoCure VOX.
   d. Euclid Chemical Co., Cleveland, OH; Kurez VOX White Pigmented.

B. Evaporation Retardant:

1. Optional: Fluorescent fugitive dye color tint that disappears completely upon drying.
2. Manufacturers and Products:
   a. BASF Construction Chemicals, Shakopee, MN; MasterKure ER 50.
   b. Euclid Chemical Co., Cleveland, OH; Eucobar.

C. Penetrating Water Repellent Sealer: Water based, ready to use, single component, silane/siloxane, penetrating, clear water repellant sealer.

1. Viscosity: 50 cps.
2. Flash Point: 200 degrees F.
3. NCHRP No. 244 Reduction in Chloride Content:
   a. Average: 82 percent.
   b. Minimum Required: 75 percent.
4. NCHRP No. 244 Reduction in Weight Gain:
   a. 21 Days: 85 percent.
   b. VOCs: 50 g/l.
   c. Depth of Penetration: 1/4 inch.
5. Manufacturers and Products:
   a. BASF Construction Chemicals, Shakopee MN; MasterProtect H 400.
   b. Euclid Chemical Co.; Baracade WB 244.

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D. Clear Liquid Densifier:

1. Colorless, aqueous solution of magnesium fluorosilicate.
2. Each gallon of solution shall contain a minimum of 2 pounds of fluorosilicate compound.
3. Manufacturers and Products:
   a. BASF Construction Chemicals, Shakopee, MN; MasterKure HD 300WB.
   b. Euclid Chemical Co., Cleveland, OH; Surfhard.

E. Water: Clean and potable, containing less than 500 ppm of chlorides.

PART 3 EXECUTION

3.01 CONCRETE CURING

A. General:

1. Cure all concrete in accordance with project specifications and ACI308.1.
2. Where surfaces are to receive coatings, painting, cementitious material, or other similar finishes, use only water curing procedures. Refer to Interior Finish Schedule for surfaces to receive coatings.
3. Use only water curing on potable water structures.
4. Where curing compound cannot be used, water curing as described below or special methods using moisture shall be agreed upon by Engineer prior to placing concrete.
5. As required in Section 03 30 00, Cast-in-Place Concrete, if result of 7-day concrete strength test is less than 50 percent of specified 28-day strength, extend period of moist curing specified below, by 7 additional days.

B. Use one of the following methods as approved by Engineer:

1. Vertical Surfaces
   a. Method 1: Leave concrete forms in place and keep surfaces of forms and concrete wet for 7 days.
   b. Method 2: Continuously sprinkle with water 100 percent of exposed surfaces for 7 days starting immediately after removal of forms.
   c. Method 3: Apply curing compound, where allowed, immediately after removal of forms.
2. Horizontal Surfaces:
   a. Method 1: Protect surface by water ponding for 7 days.
   b. Method 2: Cover with burlap or cotton mats and keep continuously wet for 7 days.

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c. Method 3: Cover with 1-inch layer of wet sand, earth, or sawdust, and keep continuously wet for 7 days.
d. Method 4: Continuously sprinkle exposed surface for 7 days.
e. Method 5: Apply curing compound, where allowed, immediately after final finishing when surface will no longer be damaged by traffic.

3.02 EVAPORATION RETARDANT APPLICATION

A. Use on flatwork when environmental conditions are anticipated to cause rapid drying of the concrete surface. Do not use evaporation retardant on potable water structures, unless product is NSF 61 approved.

B. Spray onto surface of fresh flatwork concrete immediately after screeding to react with surface moisture.

C. Reapply as needed to ensure a continuous moist surface until final finishing is completed.

3.03 PENETRATING WATER REPELLENT SEALER APPLICATION

A. Apply where indicated on Interior Finish Schedule.

B. Before application and with Work above completed, water cure concrete walls and floors for a minimum of 28 days to receive sealer, keep clean, unpainted, and free from membrane curing compounds.

C. Concrete to receive penetrating sealer shall be dry for a minimum 24 hours immediately prior to application.

D. Apply per manufacturer’s recommendations utilizing low pressure airless spray equipment.

1. Actual coverage and number of coats to be determined by field test sample application and water absorption testing. Final approval by Owner is required.

E. Apply at a coverage rate of 125 square feet per gallon to 200 square feet per gallon. Cure penetrating sealer on slabs for the minimum time recommended by manufacturer prior to allowing foot or vehicular traffic.

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3.04 CLEAR LIQUID DENSIFIER APPLICATION

A. Apply where indicated in Interior Finish Schedule.

B. Before application and with Work above completed, water cure concrete walls and floors for a minimum of 28 days to receive sealer, keep clean, unpainted, and free from membrane curing compounds.

C. Apply liquid densifier evenly, using three coats, allowing 24 hours between coats.

1. First coat 1/3 strength, second coat 1/2 strength, and third coat 2/3 strength, mix with water.
2. Apply each coat so as to remain wet on surface for 15 minutes.
3. Apply approved liquid densifier in accordance with manufacturer's instructions.
4. After final coat is completed and dry, remove surplus liquid densifier from surface by scrubbing and mopping with water.

3.05 MANUFACTURER'S SERVICES

A. Provide manufacturer's representative at Site for installation assistance, inspection, and certification of proper installation for products specified.

B. Provide penetrating water repellent sealer manufacturer's representative to demonstrate proper application of product.

C. Provide clear liquid densifier manufacturer's representative to demonstrate proper mixing and application of product.

D. Provide curing compound manufacturer's representative to demonstrate proper application of curing compound to show coverage in one coat.

END OF SECTION

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SECTION 03 40 00
PRECAST CONCRETE

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Concrete Institute (ACI): 304R, Guide for Measuring, Mixing, Transporting, and Placing Concrete.
2. ASTM International (ASTM):
   a. A36, Standard Specification for Structural Steel.
   b. A416, Standard Specification for Steel Strand, Uncoated Seven-Wire for Prestressed Concrete.
   c. C31, Standard Practice for Making and Curing Concrete Test Specimens in the Field.
3. Precast/Prestressed Concrete Institute (PCI):
   a. MNL-117, Manual for Quality Control for Plants and Production of Architectural Precast Concrete Products.
   b. MNL-120, Design Handbook for Precast and Prestressed Concrete, Third Edition.

1.02 SUBMITTALS

A. Action Submittals:

1. Retardant for Exposed Aggregate Finish:
   a. Technical data.
   b. Instructions for product application.
2. Bond Breaker for Tilt-Up Walls:
   a. Technical data.
   b. Evidence of successful use in this type of application.
   c. Instructions for product mixing/application.
3. Sealer for Exterior Surfaces: Product data with mixing/application instructions.
4. Form Liners: Manufacturer’s literature and product data.
5. Calculations and Technical Data: Proposed details and design calculations for stresses in all critical sections of precast members for all loading conditions including transportation, handling, and erection.
   a. Tilt-Up Panel Walls: Show type and location of inserts, extra reinforcement for handling, and other pertinent data for proposed tilt-up construction.

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B. Informational Submittals:

1. For Precasting Manufacturers Not Listed in Article Quality Assurance:
   a. Experience record on production of precast concrete as shown, with information on precasting plant, that will indicate capability to satisfactorily perform the Work.
   b. Evidence of current PCI plant certification.
   c. Complete list of architectural panelwork accomplished in past 2 years, including:
      1) Type of structure.
      2) Name of owner.
      3) Address of completed work.
2. Certificate of Compliance: Certify admixtures and concrete do not contain calcium chloride.
3. Test Reports:
   a. For precast manufacturer's concrete test cylinders.
   b. Inspection of installed panels.

1.03 QUALITY ASSURANCE

A. Qualifications of Precasting Manufacturers:

1. Precast Concrete and Precast Prestressed Concrete: Product of manufacturer with 3 years' experience producing precast concrete products of quality specified.
2. Precast Plant: PCI certified plant with current certification.
3. Precasting Manufacturers with Apparent Capability to Meet These Specifications:
   a. **[A: .]**
   b. **[B: .]**
   c. **[C: .]**
4. Calculations stamped by an engineer registered in the same state as the Project.

B. Samples for Exposed Aggregate Finish:

1. Before starting tilt-up panels, provide two Sample concrete panels for each aggregate finish required, 4 feet square and 3 inches thick for Engineer's approval.
2. Vary amounts of retardant to be used.
3. Approved Finish: Constitutes standard of quality required in completed Work.

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C. Mockup Panels for Architectural Precast Panels:

1. Review Sample in Engineer's office as a guide in preparation of mockup panels.
2. Construct:
   a. One full-size mockup panel for each different type of color or finish as shown to be used and installed in their respective places after approval of final precast Shop Drawings and calculations.
   b. In accordance with details shown using materials, forming systems, reinforcing details, cast-in inserts, and mix proportions, and as specified and approved.
3. Finish:
   a. Uniform in appearance and similar in all respects to Samples on display in Engineer's office.
   b. Constitutes standard of quality required in completed Work.
4. If mockup panel does not represent quality required, construct additional mockup panels until approved by Engineer.
5. Protect and maintain approved mockup panels at location selected by Engineer or until Engineer approves installation in their respective locations in the Project.

PART 2 PRODUCTS

2.01 MATERIALS

A. Formwork:

1. One-piece, full length and without seams.
2. As specified in Section 03 10 00, Concrete Forming and Accessories.

B. Reinforcing Steel: As specified in Section 03 21 00, Reinforcing Steel.

C. Cement: As specified in Section 03 30 00, Cast-in-Place Concrete.

D. Pretensioning Strands: Seven-wire, uncoated, stress relieved, ASTM A416, Grade 270.

E. Aggregates: As specified in Section 03 30 00, Cast-in-Place Concrete, for 3/4-inch maximum size. Furnish of consistent quality, gradation, and color for precast architectural panels to produce uniformity of appearance in all panels.

F. Admixtures: As specified in Section 03 30 00, Cast-in-Place Concrete.

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G. Embedded Items:

1. ASTM A36 steel.
2. Anchor Studs: Headed anchor studs (HAS), deformed bar anchors (DBA), or threaded studs as manufactured by Nelson Stud Welding Co., Lorain, OH.
3. Furnish inserts for lifting tilt-up walls, bolting stiffeners, attaching braces, and as otherwise required.

H. Grout: Nonshrink, nonmetallic Type II grout as specified in Section 03 62 00, Nonshrink Grouting.

I. Retardant for Exposed Aggregate Finish Manufacturers:

1. Sika Chemical Corp.; Rugasol.
2. Burke Co.; Exposed Aggregate Compound.

J. Sealer for Exterior Surfaces:

1. Silane Sealer: One-component penetrating sealer, hydrophilic (isopropyl alcohol as a carrier) with 40 percent active ingredients.
2. Manufacturers:
   a. Master Builders Co.
   b. Euclid Chemical Co.

K. Bond Breaker for Tilt-up Walls: Nonstaining, effective as a parting compound, will not leave film, quick drying, nontacky, rainproof, and provides reasonable abrasion resistance.

1. Manufacturers:
   a. Cresset Chemical Co.
   b. The Burke Co.

L. Precast Prestressed Concrete Members: **[A: girders,] [B: single tees,] [C: double tees,] [D: voided slabs,] [E: ,] [F:]** feet wide by **[G:]** feet deep.

2.02 CONCRETE MIX

A. As specified in Section 03 30 00, Cast-in-Place Concrete.

B. Design Strength: **[A: 5,000] [B:]** psi at 28 days.

C. Water/Cement Ratio: 0.38 maximum.

D. For colored precast concrete, coordinate ingredients and procedures to achieve uniformity of color.

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2.03 DESIGN REQUIREMENTS

A. Precast Architectural Wall Panels:

1. Crack Control: PCI MNL-120.
2. Stresses: Limit tensile stress in the panels, from all handling and installation loads, to that less than that which would cause cracking on the exposed face.
3. Impact Design: Minimum 50 percent of member weight.
4. Tensile Stresses: Do not exceed those recommended in Chapter 5 of above referenced manual for a safety factor of 1.5 in critical sections under all loading conditions.
5. Design and reinforce to withstand handling and erection loads.

B. Structural Precast and Prestressed Members, Except for Architectural Panels:

1. Meet applicable sections of PCI MNL-120.
2. Design for spans and superimposed live and dead loads shown plus dead loads of members.

C. Prestressed Members:

1. Calculated tension at full service loads shall not exceed six times the square root of design strength except that in wet or corrosive service conditions and in **[A: ,]** the calculated tension due to live load and dead load shall not exceed zero.
2. Limit long-term camber growth to span length divided by 360.

D. Tilt-Up Wall Panels:

1. Furnish design for pickup and bracing attachments and location thereof required to lift panels.
2. Pickup point locations where shown are intended only as a guide.
3. Meet design requirements specified for Precast Architectural Wall Panels.

2.04 FABRICATION

A. General:

1. Comply with PCI MNL-117.
2. Reinforcing Steel and Pretensioning Strands:
   a. Place in position before concrete is cast.
   b. Keep clean and free from form oil or other substances harmful to bond.

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3. Pretensioning Force, if Used: Determine by elongation and by gauge pressure.
    a. Method: Meet requirements of Prestressed Concrete Institute.
4. Forms: Produce smooth surfaces.
5. Concrete: Deposit, vibrate, finish, and cure in accordance with recommended practices of ACI 304R. Steam curing is permitted.
6. Release Strength for Pretensioning Method: Minimum 4,000 psi, unless otherwise approved.
7. Coordinate dimensions, determine type, quantity, size, and location of, and furnish necessary embedded items in precast concrete. Coordinate location of embedded items in cast-in-place concrete necessary to connect precast items.

B. Surface Finish for Precast Structural Units: Furnish concrete finish, as specified in Section 03 30 00, Cast-in-Place Concrete, to additional concrete field placed on precast units.

1. Other Surfaces: Smooth screeded finishes, unless otherwise shown.

C. Surface Finish for Precast Architectural Panels or Tilt-Up Walls:

1. Exposed Surfaces in Building Interior: As shown.
2. Panel Interior Surface: **[A: As shown.] [B: Steel trowel, Type S-1, as specified in Section 03 30 00, Cast-in-Place Concrete.]**
3. Meet standard of quality represented by approved mockup panel.
4. Furnish panels from same manufacturer.

D. Sealer:

1. Apply to **[A: exterior surfaces of architectural panels,] [B: ,]** at **[C: precast plantsite,] [D: at Site,] [E: after sandblasting panels,]** in accordance with manufacturer's instructions.
2. Protect surface until installed in the Work.
3. Repair damage as approved by manufacturer.

2.05 SOURCE QUALITY CONTROL

A. Prepare minimum three standard concrete test cylinders for each 50 cubic yards or fraction thereof of concrete placed in the precast work in accordance with ASTM C31.

B. Test and record concrete strengths.

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PART 3 EXECUTION

3.01 ERECTION

A. Verify that anchorage inserts are in correct locations.

B. Handle and erect precast concrete with care as recommended by manufacturer.

C. Erect precast units plumb, straight, level, square, and in proper alignment.

D. Fasten units securely in place and brace to maintain position, stability, and alignment until permanently connected and structure is complete and stable.

E. Field Cutting: Not allowed without prior approval of Engineer.

3.02 TILT-UP PANEL WALLS

A. General: Plan operation so no equipment for raising slabs is placed on concrete floors.

B. Casting Slab:

1. Use finished concrete floor.
2. Cast tilt-up panels on this slab, unless otherwise approved.
3. Do not cast panels on warped surfaces, across construction joints, or surfaces pitched to drain outlets.
4. Bond Breaker: Apply in accordance with manufacturer's recommendations.

C. Casting Slab:

1. Finished Slab: True and level plane with smooth trowel finish.
2. Bond Breaker: Apply in accordance with manufacturer's recommendations as approved.

D. Reglets: Install in forms in straight lines in accordance with manufacturer's recommendations.

E. Exposed Aggregate Finish:

1. Retardant Application:
   a. Shake uniformly over freshly placed concrete surface immediately following finishing process and before all surface water has disappeared.

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b. Rate: To effect a depth of 1/8 inch or more exposure of aggregate, as approved.
c. In accordance with manufacturer's recommendations.

2. Curing: Cover with wet burlap or other acceptable covering and maintain in a moist state.
3. Hose or brush off retarded concrete surface to expose clean aggregate.
4. After retarded concrete has been removed, cure panels in the manner specified in Section **[A: 03 39 00, Concrete Curing] [B:]**.
5. Where sides of panels are to be exposed aggregate, paint forms with two coats of retardant before placing concrete.
6. Finish: To match Sample approved by Engineer.

F. Lifting and Setting Panels in Position:

1. Caution: Walls or panels are not stable in themselves against lateral loads, such as wind until construction is complete. Provide bracing as required.
2. Do not move panels until concrete has obtained the design field strength required by design calculation for handling stresses, including impact. Field strength shall be determined by test cylinders.
3. Pickup Lines: Provide equal lifting force at panel pickup points, applied simultaneously and acting at right angles to panel.
4. Excessive Stresses or Shock Loading: Prevent when lifting panel from casting surface, consider form suction and impact using Part 5 of PCI MNL-120 Design Handbook.
5. Lifting Equipment: Of size and capacity to prevent damage to panel.
6. Set panels on carefully leveled shims.
7. Position, plumb and align true to line, and brace securely.
8. Bottom Joint Space: Fill with nonshrink nonmetallic grout as shown and as specified in Section 03 62 00, Nonshrink Grouting, as soon as panels are placed and braced.
9. Insert Holes: Fill with nonshrink nonmetallic grout.
10. Holes in Exposed Surfaces: Patch to match adjacent surfaces.
11. Make welded connections.

G. Cast-In-Place Pilasters and Closing Sections: As specified in Section 03 30 00, Cast-in-Place Concrete.

3.03 PATCHING

A. Mix and place patching mixture to match color and texture of surrounding concrete and to minimize shrinkage.

B. Demonstrate patching method and obtain acceptance and approval.

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3.04 CLEANING

A. After installation, clean soiled precast concrete surfaces with detergent and water, using fiber brush and sponge.

B. Use acid solution only to clean particularly stubborn stains after more conservative methods have been tried unsuccessfully.

C. Use extreme care to prevent damage to precast concrete surfaces and to adjacent materials.

D. Rinse thoroughly with clean water immediately after using cleaner.

3.05 FIELD QUALITY CONTROL

A. Inspection:

1. With Engineer, inspect precast architectural wall panels for chips, cracks, discoloration, and other damage.
2. Compare every panel to approved mockup panel and finish sample panel.
3. Record location and condition of damaged or nonmatching panels.

B. Resolution:

1. Repair damage to satisfaction of Engineer and Owner.
2. Remove panels with damage or repairs not acceptable to Engineer.
3. Install new acceptable panels in place of those removed.
4. Perform reinspection and obtain acceptance by Engineer.

3.06 PROTECTION

A. Protect precast units from chipping, spalling, cracking, or other damage to the units after delivery to Site.

B. After erection, protect units from damage.

END OF SECTION

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SECTION 03 62 00
GROUTING

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   a. C230, Standard Specification for Flow Table for Use in Tests of Hydraulic Cement.
   b. C307, Standard Test Method for Tensile Strength of Chemical-Resistant Mortar, Grouts, and Monolithic Surfacings.
   c. C531, Standard Test Method for Linear Shrinkage and Coefficient of Thermal Expansion of Chemical-Resistant Mortars, Grouts, Monolithic Surfacings, and Polymer Concretes.
   d. C579, Standard Test Methods for Compressive Grout Strength of Chemical-Resistant Mortars, Grouts, Monolithic Surfacings, and Polymer Concretes.
   e. C882, Standard Test Method for Bond Strength of Epoxy-Resin Systems Used With Concrete By Slant Shear.
   f. C939, Standard Test Method for Flow of Grout for Preplaced-Aggregate Concrete (Flow Cone Method).
   g. C940, Standard Test Method for Expansion and Bleeding of Freshly Mixed Grouts for Preplaced-Aggregate Concrete in the Laboratory.
   h. C1107/C1107M, Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink).
   i. C1181, Standard Test Methods for Compressive Creep of Chemical-Resistant Polymer Machinery Grouts.
   j. D4263, Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method.

1.02 SUBMITTALS

A. Action Submittals:

1. Product data of grouts.
2. Proposed method for keeping existing concrete surfaces wet prior to placing nonshrink grout.
3. Forming method for fluid grout placements.
4. Curing method for grout.

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B. Informational Submittals:

1. Manufacturer's Written Instructions:
   a. Adding fiber reinforcing to batching.
   b. Mixing of grout.
2. Manufacturer's proposed training schedule for grout work.
3. Manufacturer's Certificate of Compliance in accordance with Section 01 61 00, Common Product Requirements.
   a. Grout free from chlorides and other corrosion-causing chemicals.
   b. Nonshrink grout properties of Category II verifying expansion at 3 days or 14 days will not exceed the 28-day expansion and nonshrink properties are not based on gas or gypsum expansion.
4. Manufacturer's Certificate of Proper Installation.
5. Statements of Qualification: Grout manufacturer's representative.
6. Test Reports:
   a. Test report for 24-hour evaluation of nonshrink grout.
   b. Test results and service report from demonstration and training session.
   c. Field test reports and laboratory test results for field-drawn Samples.
7. List of Contractor's equipment installation staff trained by grout manufacturer's representative in:
   a. Nonshrink grout installation and curing.
   b. Epoxy grout installation and curing.

1.03 QUALIFICATIONS

A. Grout Manufacturer's Representative: Authorized and trained representative of grout manufacturer. Minimum of 1-year experience that has resulted in successful installation of grouts similar to those for this Project.

B. For grout suppliers not listed herein, provide completed 24-hour Evaluation of Nonshrink Grout Test Form, attached at the end of this section. Provide independent testing laboratory test results for testing conducted within last 18 months.

PART 2 PRODUCTS

2.01 NONSHRINK GROUT AND EPOXY GROUT SCHEDULE

A. Furnish nonshrink grout (Category I or II) and epoxy grout for applications as indicated in the following schedule:

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Application	Temperature Range	Max. Placing Time	
	40 deg F to 100 deg F	20 Min.	Greater Than 20 Min.
Blockouts for gate guides	I or II		II
Precast joints	I or II		II
Column baseplates single-story	I or II		II
Machine bases 25 hp or less	II	II	II
Bases for precast wall sections	II	II	II
Baseplates for columns over one story	II	II	II
Precast base joints higher than one story	II	II	II
Form Tie-Through bolt openings	II	II	II
Machine bases 26 hp and up	Epoxy Grout	Epoxy Grout	Epoxy Grout
Baseplates and/or soleplates with vibration, thermal movement, etc.	Epoxy Grout	Epoxy Grout	Epoxy Grout

2.02 NONSHRINK GROUT

A. Category I:

1. Nonmetallic and nongas-liberating.
2. Prepackaged natural aggregate grout requiring only the addition of water.
3. Test in accordance with ASTM C1107/C1107M:
   a. Grout shall have flowable consistency.
   b. Flowable for 15 minutes.
4. Grout shall not bleed at maximum allowed water.
5. Minimum strength of flowable grout, 3,000 psi at 3 days, 5,000 psi at 7 days, and 7,000 psi at 28 days.
6. Manufacturers and Products:
   a. BASF Building System, Inc., Shakopee, MN; MasterFlow 100.
   b. Euclid Chemical Co., Cleveland, OH; NS Grout.

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c. Dayton Superior Corp., Miamisburg, OH; 1107 Advantage Grout.
d. US MIX Co., Denver, CO; US SPEC GP Grout.
e. Five Star Products Inc., Fairfield, CT; Five Star Grout.

B. Category II:

1. Nonmetallic, nongas-liberating.
2. Prepackaged natural aggregate grout requiring only the addition of water.
3. Aggregate shall show no segregation or settlement at fluid consistency at specified times or temperatures.
4. Test in accordance with ASTM C1107/C1107M:
   a. Fluid consistency 20 seconds to 30 seconds in accordance with ASTM C939.
   b. Temperatures of 40 degrees F, 80 degrees F, and 90 degrees F.
5. 1 hour after mixing, pass fluid grout through flow cone with continuous flow.
6. Minimum strength of fluid grout, 3,500 psi at 1 day, 4,500 psi at 3 days, and 7,500 psi at 28 days.
7. Maintain fluid consistency when mixed in 1-yard to 9-yard loads in ready-mix truck.
8. Manufacturers and Products:
   a. BASF Building Systems, Inc., Shakopee, MN; MasterFlow 928.
   b. Five Star Products Inc., Fairfield, CT; Five Star Fluid Grout 100.
   c. Euclid Chemical Co., Cleveland, OH; Hi Flow Grout.
   d. Dayton Superior Corp., Miamisburg, OH; Sure Grip High Performance Grout.
   e. US MIX Co., Denver, CO; US SPEC MP Grout.

2.03 EPOXY GROUT

A. High-strength, nonshrink, high-temperature epoxy grouting material developed for the support of heavy equipment with vibratory loads.

B. Three-component mixture of a two-component epoxy resin system (100 percent solids) with a graded, precision aggregate blend.

C. Premeasured, prepackaged system.

D. Flowable.

E. Minimum compressive strength in accordance with ASTM C579 Method B, 9,500 psi at 75 degrees F at 7 days, 11,000 psi at post cure.

F. Maximum creep resistance in accordance with ASTM C1181 at 600 psi, 140 degrees F; 6.0 by 10^{-3} in/in.

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G. Minimum bond strength in accordance with ASTM C882, 2,000 psi.

H. Minimum tensile strength in accordance with ASTM C307, 2,000 psi.

I. Maximum coefficient of thermal expansion in accordance with ASTM C531 at 73 degrees F to 210 degrees F, 23.0 by10^{-6} in/in/degrees F.

J. Working Time: Minimum 2 hours at 50 degrees F; 1.5 hours at 70 degrees F; 50 minutes at 90 degrees F.

K. Good chemical resistance.

L. Good effective bearing area.

M. Noncorrosive.

N. Moisture insensitive.

O. Modify resin and aggregate content where recommended by epoxy grout manufacturer to provide desired epoxy grout flow properties.

P. Manufacturer and Product:

1. BASF Building System, Inc., Shakopee MN; MasterFlow 648.
2. Euclid Chemical Co., Cleveland, OH; E^3-G.
3. Dayton Superior Corp., Miamisburg, OH; Pro-Poxy 2000 Normal Set.
4. Five Star Products Inc., Fairfield, CT; DP Epoxy Grout.

PART 3 EXECUTION

3.01 GROUT

A. General: Mix, place, and cure grout in accordance with grout manufacturer's representative's training instructions.

B. Epoxy Grout: Concrete slab shall be fully cured for 28 days to ensure excess water has evaporated. Test concrete surface for moisture in accordance with ASTM D4263 before epoxy grout is placed.

C. Form Tie-Through Bolt Holes: Provide nonshrink grout, Category II, fill space with dry pack dense grout hammered in with steel tool and hammer. Through-bolt holes; coordinate dry pack dense grout application with vinyl plug in Section 03 10 00, Concrete Forming and Accessories, and bonding agent in Section 03 30 00, Cast-in-Place Concrete.

D. Form Snap-Tie Hole: Fill tie hole in accordance with requirements of Section 03 30 00, Cast-in-Place Concrete.

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3.02 GROUTING MACHINERY FOUNDATIONS

A. Block out original concrete or finish off at distance shown below bottom of machinery base with grout. Prepare concrete surface by sandblasting, chipping, or by mechanical means to remove any soft material. Surface roughness in accordance with manufacturer's written instructions.

B. Clean metal surfaces of all paint, oil, grease, loose rust, and other foreign material that will be in contact with grout.

C. Sandblast to bright metal all metal surfaces in contact with epoxy grout in accordance with manufacturer's written instructions.

D. Set machinery in position and wedge to elevation with steel wedges, or use cast-in leveling bolts. Remove wedges after grout is set and pack void with grout.

E. Form with watertight forms at least 2 inches higher than bottom of plate.

F. Fill space between bottom of machinery base and original concrete in accordance with manufacturer's representative's training instructions.

G. If grout cannot be placed from one edge and flowed to the opposite edge, air vents shall be provided through the plate to prevent air entrapment.

H. Radius all corners of grout pad.

I. Install expansion joints for epoxy grout placement in accordance with manufacturer's written instructions.

3.03 TANK FOUNDATIONS

A. Prepare concrete surface by sandblasting, chipping, or by mechanical means to remove any soft material. Surface roughness in accordance with manufacturer's written instructions.

B. Clean metal surfaces of all paint, oil, grease, loose rust and other foreign material that will be in contact with grout.

C. Set tank in position and wedge to elevation with steel wedges, or use cast-in leveling bolts. Remove wedges after grout is set and pack void with grout.

D. Form with watertight forms at least 2 inches higher than bottom of plate.

E. Fill space between bottom of tank base and original concrete in accordance with manufacturer's representative's training instructions.

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3.04 FIELD QUALITY CONTROL

A. General:

1. Performed by Project representative's inspection staff.
2. Perform the following quality control inspections. The grout manufacturer's representative shall accompany the Project representative's inspection staff on the first installation of each size and type of equipment.

B. Evaluation and Acceptance of Nonshrink Grout:

1. Inspect the surface preparation of concrete substrates onto which nonshrink grout materials are to be applied, for conformance to the specified application criteria including, but not limited to, substrate profile, degree of cleanliness, and moisture.
2. Inspect preparation and application of nonshrink grout form work for conformance to the manufacturer's recommendations.
3. Conduct a final review of completed nonshrink grout installation for conformance to these Specifications.
4. Provide a flow cone and cube molds with restraining plates onsite. Continue tests during Project as demonstrated by grout manufacturer's representative.
5. Perform flow cone and bleed tests, and make three 2-inch by 2-inch cubes for each 25 cubic feet of each type of nonshrink grout used. Use restraining caps for cube molds in accordance with ASTM C1107/ C1107M.
6. For large grout applications, make three additional cubes and one more flow cone test. Include bleed test for each additional 25 cubic feet of nonshrink grout placed.
7. Consistency: As specified in Article Nonshrink Grout. Flow cone test in accordance with ASTM C939. Grout with consistencies outside range requirements shall be rejected.
8. Segregation: As specified in Article Nonshrink Grout. Grout when aggregate separates shall be rejected.
9. Nonshrink grout cubes shall test equal to or greater than minimum strength specified.
10. Strength Test Failures: Nonshrink grout work failing strength tests shall be removed and replaced.
11. Perform bleeding test in accordance with ASTM C940 to demonstrate grout will not bleed.
12. Store cubes at 70 degrees F.
13. Independent testing laboratory shall prepare, store, cure, and test cubes in accordance with ASTM C1107/C1107M.

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14. All grout, already placed, which fails to meet the requirements of these Specifications, is subject to removal and replacement at no additional cost to the Owner.

C. Evaluation and Acceptance of Epoxy Grout:

1. Inspect ambient conditions during various phases of epoxy grouting installation for conformance with the epoxy grout manufacturer's requirements.
2. Inspect the surface preparation of concrete substrates onto which epoxy grout materials are to be applied, for conformance to the specified application criteria including, but not limited to, substrate profile, degree of cleanliness, and moisture.
3. Inspect the surface preparation of the metallic substrates onto which the epoxy primer is to be applied.
4. Inspect the epoxy-primed metallic substrate for coverage and adhesion.
5. Inspect preparation and application of epoxy grout form work for conformance to the manufacturer's recommendation.
6. Verify consistency obtained is sufficient for the proper field placement at the installed temperatures.
7. Inspect and record that the "pot life" of epoxy grout materials is not exceeded during the installation.
8. Inspect epoxy grout for cure.
9. Inspect and record that localized repairs made to grout voids are in conformance with the specification requirements.
10. Conduct a final review of completed epoxy grout installation for conformance to these Specifications.
11. Compression tests and fabrication of specimens for epoxy grout shall be made in accordance to ASTM C579, Method B, at intervals during construction as selected by the Project representative. A set of three specimens shall be made for testing at 7 days, and each earlier time period as appropriate.
12. Independent testing laboratory shall prepare, store, cure, and test cubes in accordance with ASTM C579.
13. All grout, already placed, which fails to meet the requirements of these Specifications, is subject to removal and replacement at no additional cost to the Owner.

3.05 MANUFACTURER'S SERVICES

A. General:

1. Coordinate demonstrations, training sessions, and applicable Site visits with grout manufacturer's representative. Allow 2-week notice to grout manufacturer's representative for scheduling purposes.

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2. Provide and conduct onsite, demonstration and training sessions for bleed tests, mixing, flow cone measurement, cube testing, application, and curing for each category and type of grout.
3. Necessary equipment and materials shall be available for demonstration.
4. Conduct training prior to equipment mount installation work on equipment pads.
5. Training for each type of grout shall be not less than 4 hours' duration.

B. Nonshrink Grout Training:

1. Training is required for all Type II grout installations.
2. Provide nonshrink grout installation training by the qualified grout manufacturer's representative for Contractor's workers that will be installing nonshrink grout for baseplates and equipment mounts. Schedule training to allow Engineer's attendance.
3. Mix nonshrink grouts to required consistency, test, place, and cure on actual Project, such as, baseplates and form tie-through bolt holes to provide actual on-the-job training.
4. Use minimum of two bags for grout Category II. Mix grout to fluid consistency and conduct flow cone and two bleed tests, make a minimum of six cubes for testing of two cubes at 1 day, 3 days, and 28 days. Use remaining grout for final Work.
5. Include recommended grout curing methods in the training.
6. Transport test cubes to independent test laboratory and obtain test reports.
7. Training by manufacturer's representative does not relieve Contractor of overall responsibility for this portion of the work.
8. Submit a list of attendees that have been satisfactorily trained to perform epoxy grout installation for equipment mounting.

C. Epoxy Grout Training:

1. Provide epoxy grout installation training by the qualified epoxy grout manufacturer's representative for Contractor's workers that will be installing epoxy grout for equipment mounts. Schedule training to allow Engineer's attendance.
2. Include training in:
   a. Performance testing such as compressive strength testing of the epoxy grout.
   b. All aspects of using the products, from mixing to application.
3. Transport test cubes to independent test laboratory and obtain test reports.
4. Training by manufacturer's representative does not relieve Contractor of overall responsibility for this portion of the work.
5. Submit a list of attendees that have been satisfactorily trained to perform epoxy grout installation for equipment mounting.

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3.06 SUPPLEMENTS

A. The supplement listed below, following “End of Section,” is part of this Specification.

1. 24-hour Evaluation of Nonshrink Grout Test Form and Grout Testing Procedures.

END OF SECTION

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SUPPLEMENT 1

_____

(Test Lab Name)

_____

(Address)

_____

(Phone No.)

24-HOUR EVALUATION OF NONSHRINK GROUT TEST FORM

OBJECTIVE: Define standard set of test procedures for an independent testing laboratory to perform and complete within a 24-hour period.

SCOPE: Utilize test procedures providing 24-hour results to duplicate field grouting demands. Intent of evaluation is to establish grout manufacturer's qualifications.

PRIOR TO TEST: Obtain three bags of each type of grout.

1. From intended grout supplier for Project.
2. Three bags of grout shall be of same lot number.

ANSWER THE FOLLOWING QUESTIONS FOR GROUT BEING TESTED FROM LITERATURE, DATA, AND PRINTING ON BAG:

A.	Product data and warranty information contained in company literature and data?	Yes_____ No_____
B.	Literature and bag information meet specified requirements?	Yes_____ No_____
C.	Manufacturer guarantees grout as specified in Article Guarantee?	Yes_____ No_____
D.	Guarantee extends beyond grout replacement value and allows participation with Contractor in replacing and repairing defective areas?	Yes_____ No_____
E.	Water demands and limits printed on bag?	Yes_____ No_____
F.	Mixing information printed on the bag?	Yes_____ No_____
G.	Temperature restrictions printed on bag?	Yes_____ No_____

*Rejection of a grout will occur if one or more answers are noted NO.

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GROUT TESTING PROCEDURES

A. Bagged Material:

1. List lot numbers. _____
2. List expiration date. _____
3. Weigh bags and record weight. _____

Owner's Representative will disqualify grout if bag weights have misstated measure plus or minus 2 pounds by more than one out of three bags. (Accuracy of weights is required to regulate amount of water used in mixing since this will affect properties.)

B. Mixing and Consistency Determination:

1. Mix full bag of grout in 10-gallon pail.
2. Use electric drill with a paddle device to mix grout (jiffy or jiffler type paddle).
3. Use maximum water allowed per water requirements listed in bag instructions.
4. Mix grout to maximum time listed on bag instructions.
5. In accordance with ASTM C939 (flow cone) determine time of mixed grout through the flow cone. _____ seconds
6. Add water to attain 20- to 30-second flow in accordance with ASTM C939.
7. Record time of grout through cone at new water demand. _____ seconds
8. Record total water needed to attain 20- to 30-second flow. _____ pounds
9. Record percent of water. _____ percent

C. When fluid grout is specified and additional water is required beyond grout manufacturer's listed maximum water, ASTM C1107/C1107M will be run at new water per grout ratio to determine whether grout passes using actual water requirements to be fluid. Use new water per grout ratio on remaining tests.

D. Bleed Test:

1. Fill two gallon cans half full of freshly mixed grout at ambient temperatures for each category and at required consistency for each.
2. Place one can of grout in tub of ice water and leave one can at ambient temperature.
3. Cover top of both cans with glass or plastic plate preventing evaporation.
4. Maintain 38 degrees F to 42 degrees F temperature with grout placed in ice and maintain ambient temperature for second container for 1 hour.
5. Visually check for bleeding of water at 15-minute intervals for 2 hours.

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6. Perform final observation at 24 hours.

If grout bleeds a small amount at temperatures specified, grout will be rejected.

E. Extended Flow Time and Segregation Test (for Category II and Category III):

1. Divide the remaining grout into two 3-gallon cans. Place the cans into the 40-degree F and 90-degree F containers and leave for 20, 40, and 60 minutes. Every 20 minutes remove and check for segregation or settlement of aggregate. Use a gloved hand to reach to the bottom of the can, if more than 1/4 inch of aggregate has settled to the bottom or aggregate has segregated into clumps reject the grout.

2. Right after the settlement test mix the grout with the drill mixer for 10 seconds. Take a ASTM C939 flow cone test of grout and record flow time. Maintain this process for 1 hour at ambient temperatures of 40 degrees F and 90 degrees F.

   a. 20 min _____, sec. @ 40 degrees F.

   b. 40 min _____, sec. @ 40 degrees F.

   c. 60 min _____, sec. @ 40 degrees F.

   d. 20 min _____, sec. @ 90 degrees F.

   e. 40 min _____, sec. @ 90 degrees F.

   f. 60 min _____, sec. @ 90 degrees F.

All Category II and Category III grout that will not go through the flow cone with continuous flow after 60 minutes will be disqualified.

_____ _____

Qualified Disqualified

F. 24-hour Strength Test:

1. Using grout left in mixing cans in accordance with ASTM C1107/C1107M for mixing and consistency determination test and for extended time flow test, make minimum of nine cube samples.

2. Store cubes at 70 degrees F for 24 hours.

3. Record average compressive strength of nine cubes at 24 hours.

Grout will be disqualified if 24-hour compressive strengths are less than 2,500 psi for grouts claiming fluid placement capabilities.

Grouts that have not been disqualified after these tests are qualified for use on the Project for the application indicated in Nonshrink Grout Schedule.

_____ _____

Signature of Independent Testing Laboratory Date Test Conducted

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SECTION 03 63 00
CONCRETE DOWELING

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards that may be referenced in this section:

1. American National Standards Institute (ANSI).
2. ASTM International (ASTM):
   a. C881/C881M, Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete.
   b. E488, Standard Test Methods for Strength of Anchors in Concrete and Masonry Elements.
3. International Code Council (ICC):
   a. 2012 International Building Code (IBC).
   b. Evaluation Services Reports.
4. NSF International (NSF): 61, Drinking Water System Components – Health Effects.

1.02 DEFINITIONS

A. ICC Evaluation Services Report: Published by ICC for products provided by concrete adhesive anchor manufacturers.

B. Special Inspection: As defined in the ICC IBC and indicated on the Statement of Special Inspection (Plan) on the Drawings.

1.03 SUBMITTALS

A. Action Submittals:

1. Product Data: Manufacturer’s catalog information.

B. Informational Submittals:

1. Manufacturer’s instructions for preparation, placement, drilling of holes, installation of anchors and adhesive, and handling of cartridges, nozzles, and equipment.
2. Manufacturer’s written letter of certification identifying installer’s qualifications to install products.
3. ICC Evaluation Services Report: Specific to proposed doweling system manufacturer.

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1.04 QUALITY ASSURANCE

A. Qualifications:

1. Manufacturer: At least three similar projects with same products within last 3 years.
2. Installer: Trained and certified by manufacturer.

B. Regulatory Requirements: Adhesive shall be certified as meeting NSF 61 for use in potable water structures.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Container Markings: Include manufacturer's name, product name, batch number, product expiration date, ANSI hazard classification, and appropriate ANSI handling precautions.

B. Store adhesive components in accordance with manufacturer's written instructions.

C. Dispose of when:

1. Shelf life has expired.
2. Stored other than per manufacturer's instructions.

PART 2 PRODUCTS

2.01 MATERIALS

A. Adhesive:

1. Approved by an ICC Evaluation Services Report for conformance to 2012 IBC requirements for doweling of steel reinforcing bars in cracked concrete.
2. Suitable for long-term loads as well as for wind and seismic loads.
3. Meet requirements of ASTM C881/C881M.
4. Two-component, insensitive to moisture, designed to be used in adverse freeze/thaw environments.
5. Disposable, Self-Contained Cartridge System:
   a. Capable of dispensing both components in proper mixing ratio.
   b. Fit into manually or pneumatically operated caulking gun.
6. Cure Temperature, Pot Life, and Workability: Compatible for intended use and anticipated environmental conditions.
7. Potable Water Structures: Adhesive shall be acceptable for use by NSF 61.

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8. Manufacturers and Products:
    a. Hilti, Inc., Tulsa, OK; HIT-RE 500-SD (ESR-2322) or HIT-HY 200 (ESR-3187) Adhesive Anchors.
    b. Powers Fasteners, Brewster, NY; Power PURE110+ Epoxy Adhesive Anchor System (ESR-3298).
    c. Simpson Strong-Tie Co., Inc., Pleasanton, CA; SET-XP Epoxy Adhesive Anchors (ESR-2508).

B. Mixing Nozzles: Disposable, manufactured in several sizes to accommodate size of reinforcing dowels.

C. Reinforcing Dowels: As specified in Section 03 21 00, Steel Reinforcement.

PART 3 EXECUTION

3.01 INSTALLATION

A. Drilling Equipment:

1. Drilling Hammers for Dowel Holes:
    a. Electric or pneumatic rotary type with medium or light impact.
    b. Hollow drills with flushing air systems are preferred.
2. Where edge distances are less than 2 inches, use lighter impact equipment to prevent microcracking and concrete spalling during drilling process.

B. Hole Diameter: Use drill bit diameter meeting ICC Evaluation Services Report requirements and as recommended by manufacturer.

C. Obstructions in Drill Path: When existing steel reinforcement is encountered during drilling, obtain Engineer approval for proposed fix.

D. Doweling:

1. Install per details shown on Drawings and in accordance with adhesive manufacturer's instructions.
2. When using epoxy anchors, dowels may be prebent prior to installation to 15 degrees to align with other bars. Do not heat dowels to bend.
3. Bent Bar Dowels: Where edge distances are critical, and intersection with steel reinforcement is likely, drill hole at 10-degree angle or less and use prebent reinforcing bars.

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E. Adhesive:

1. Install in accordance with written manufacturer's instructions.
2. Dispense components through specially designed static mixing nozzle that thoroughly mixes components and places mixed adhesive at base of predrilled hole.

3.02 FIELD QUALITY ASSURANCE AND QUALITY CONTROL

A. Proof Loading:

1. To be performed where continuous inspection of concrete dowels is required.
2. Testing will be performed by Owner's Independent Testing Agency.
3. Proof loading to be performed only after adhesive has achieved proper cure per manufacturer's requirements.
4. Testing will be conducted on minimum of 10 percent of installed dowels, with a minimum of two tension tests. A minimum of two cartridges per box or packaging unit will be tested.
5. Testing will be conducted in accordance with ASTM E488 and as follows:
    a. Performance of a static tension test of each test dowel.
    b. Test apparatus reaction base will not interfere with bond failure of dowel, but will preclude a concrete pullout cone failure.
    c. Each test dowel will be tested at a proof load equal to the lesser of 80 percent of the yield strength of the dowel bar or 50 percent of calculated ultimate load based on adhesive bond strength.
    d. Test load to be maintained for a minimum of 30 seconds without visible signs of movement of dowel or drop in gauge reading.
6. Failure of dowel bar or failure within base concrete will cause dowel to be rejected. For each rejected dowel, two additional dowels will be tested. Replace rejected dowels as approved by Engineer.

B. Owner-Furnished Quality Assurance, in accordance with IBC Chapter 17 requirements, is provided in the Statement of Special Inspection (Plan) on Drawings. Contractor responsibilities and related information on special inspection and testing are included in Section 01 45 33, Special Inspection, Observation, and Testing.

1. Special inspection will be performed by the Special Inspector in accordance with ICC ESR requirements and as specified in Section 01 45 33, Special Inspection, Observation, and Testing.
2. Continuous inspection required where noted on Drawings and where concrete dowels are installed in overhead applications.

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3. Periodic inspection required where continuous inspection is not specified.
4. Special Inspector will observe installation in accordance with requirements of the ICC Evaluation Services Report and will submit report including the following:
    a. Product Description: Product name, rod diameter, and length.
    b. Drill bit compliance.
    c. Hole diameter, diameter, and depth and cleanliness.
    d. Adhesive expiration date.
5. Verification of dowel installation in accordance with manufacturer's published instructions.

C. Contractor-Furnished Quality Control: Inspection and testing as required in Section 01 45 16.13, Contractor Quality Control.

END OF SECTION

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SECTION 03 64 23
EPOXY RESIN INJECTION GROUTING

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   a. C882, Standard Specification for Test Method for Bond Strength of Epoxy Resin System Used with Concrete by Slant Shear.
   b. D570, Standard Test Method for Water Absorption of Plastics.
   c. D638, Standard Test Method for Tensile Properties of Plastics.
   d. D648, Standard Test Method for Deflection Temperature of Plastics under Flexural Load in the Edgewise Position.
   e. D695, Standard Test Method for Compressive Properties of Rigid Plastics.
   f. D790, Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.
2. National Sanitation Foundation (NSF):
   a. Standard 60, Standard for Drinking Water Treatment and Chemicals – Health Effects.
   b. Standard 61, Standard for Drinking Water System Components – Health Effects.

1.02 DEFINITIONS

A. Crack: Complete or incomplete separation of concrete into two or more parts produced by breaking or fracturing.

B. Defective Area: As defined in Section 03 30 00, Cast-in-Place Concrete.

C. Hydraulic Structure: Liquid containment structure and/or structure designed to mitigate liquid infiltration.

D. Injection: Method of bonding together, addressing or eliminating leakage through cracks or joints by installing resin under pressure to fill the void in crack or joint.

E. Joint: A planned and formed discontinuity in concrete structure at junction of adjacent and sequential concrete placements and may contain embedded waterstops.

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F. Leak or Leakage: Crack or joint exhibiting presence of moisture, sign of efflorescence, intermittently wet to touch, or continuous flow of liquid.

G. Narrow Cracks: Width equal to or less than 0.015 inch.

H. Wide Cracks: Wider than 0.015 inch.

1.03 SUBMITTALS

A. Action Submittals:

1. Physical and chemical properties for epoxy resin.
2. Technical data for metering, mixing, and injection equipment.
3. Depth of penetration, length, material used, and procedures where epoxy is approved for use.
4. Marked up drawings of proposed epoxy injection repair crack locations, widths, and lengths and direction on structure.
5. Pot Life Test.
6. Slant Shear Test (Bond Strength).

B. Informational Submittals:

1. Manufacturer's recommended surface preparation procedures and application instructions for epoxy resins.
2. Manufacturer's Certificate of Compliance in accordance with Section 01 61 00, Common Product Requirements. Certified test results for each batch of epoxy resin.
3. Certificate for NSF 61 conformance.
4. Statements of Qualification for Epoxy Resin:
   a. Manufacturer's Site representative.
   b. Injection applicator.
   c. Injection pump operating technician.
5. Sample of epoxy resin two component ratio and injection pressure test records for concrete crack repair work.
6. Installation instructions for repairing core holes with repair mortar.
7. Epoxy resin two component ratio and injection pressure test records for concrete crack repair work.

1.04 QUALITY ASSURANCE

A. Qualifications for Injection Staffs:

1. Manufacturer's Site Representative:
   a. Capable of instructing successful methods of epoxy injection process for concrete structure.
   b. Understands and is capable of explaining technical aspects of correct material selection and use.

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c. Experienced in operation, maintenance, and troubleshooting of application equipment.

2. Injection Crew and Job Foreman:
   a. Provide written and verifiable evidence showing compliance with the following requirements:
      1) Licensed or certified by epoxy resin material manufacturer.
      2) Minimum 3 years' experience in successful epoxy injection for at least 10,000 linear feet of successful crack injection, including 2,000 linear feet of wet crack injection to stop water leakage.

B. Injected Epoxy Resin: Fill cracks with minimum resin depth penetration no less than 90 percent of:

1. Full thickness of concrete section for cracks or joints.

C. Injected cracks which leak shall be considered deficient work irrespective of depth of penetration. Reinjection of deficient work or, with approval of Engineer, provide other repairs to eliminate leakage.

D. Bond Strength Test for Epoxy Resin:

1. Concrete failure before resin failure.
2. 1,500 psi minimum bond strength per ASTM C882 test requirements with no failure of either concrete or epoxy resin.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Packing and Shipping:

1. Package resin material in new sealed containers and label with following information:
   a. Manufacturer's name.
   b. Product name and lot number.
   c. ANSI Hazard Classification.
   d. ANSI recommended precautions for handling.
   e. Mix ratio by volume for components.

B. Storage and Protection: Store epoxy resin material containers in accordance with manufacturer's printed instructions and at ambient temperatures below 110 degrees F and above 45 degrees F.

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PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Materials and accessories specified in this section shall be products of:

1. BASF Construction Chemicals, LLC-Building Systems, Shakopee, MN; SCB Concresive Series products that meet properties indicated in sub-section 2.2.B.
2. Sika Corp., Lyndhurst, NJ; Sikadur Series products that meet properties below.
3. Euclid Chemical Co., Cleveland, OH; Euco Series (#452) products that meet properties below.

2.02 EPOXY INJECTION RESIN

A. Two-component A and B structural epoxy resin for injection into cracks in concrete structures for bonding or grouting.

B. Uncured Resin Properties:

1. When mixed in ratio specified on resin container label:

	Test Method	Wide Cracks [A: or Joints]	Narrow Cracks [A: or Joints]
Pot Life (60-gram mass) @ 77, plus or minus 4 deg F	As specified in Article Source Quality Control	13 to 25 minutes	15 to 30 minutes
Pot Life (60-gram mass) @ 100, plus or minus 4 deg F	As specified in Article Source Quality Control	3 to 10 minutes	10 to 20 minutes
Viscosity @ 40, plus or minus 3 deg F	Brookfield RVT Spindle No. 4 @ 20 rpm	4,400 cps	600 cps
Viscosity @ 75 to 77 deg F	Brookfield RVT Spindle No. 2 @ 20 rpm	375 to 350 cps	175 to 140 cps

C. Epoxy Resin Properties: When cured for 7 days at 77 degree F, plus or minus 3 degrees F and conditioned at test temperature 12 hours prior to test, unless otherwise specified.

	Test Method	Wide Cracks or Joints	Narrow Cracks or Joints
Ultimate Tensile Strength, psi	ASTM D368	**[A: 8,000]** min.	**[A: 5,000]** min.

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	Test Method	Wide Cracks or Joints	Narrow Cracks or Joints
Tensile Elongation @ Break, percent	ASTM D638	4.2 max.	3.0 max.
Flexural Strength, psi	ASTM D790	10,000 min.	10,000 min.
Flexural Modulus, psi	ASTM D790	5.5 x 10^5 min.	4.5x10^5 min.
Compressive Yield Strength, psi	ASTM D695*	15,000 min.	12,000 min.
Compressive Modulus, psi	ASTM D695*	4.0x10^5 min.	4.0x10^5 min.
Heat Deflection Temperature	ASTM D648*	130 deg F min.	140 deg F min.
Cured 3 days @ 40 deg F – Wet Concrete		3,500 psi min.	3,500 psi min.
Cured 1 day @ 77 deg F – Dry Concrete		5,000 psi min.	5,000 psi min.
Cured 3 days @ 77 deg plus or minus 3 deg F		5,000 psi min.	5,000 psi min.
*Cure test specimens so that peak exothermic temperature of resin does not exceed 100 degrees F. Note: See referenced specifications for preparation method of test specimens.			

2.03 SURFACE SEAL

A. Sufficient strength and adhesion for holding injection fittings firmly in place and to resist pressures preventing leakage during injection.

B. Capable of removal after injection resin has cured.

2.04 WATER

A. Clean and free from oil, acid, alkali, organic matter, or other deleterious substances, meeting federal ANSI/NSF Standard 60 drinking water standards.

2.05 SAMPLE BOTTLE

A. Five-inch natural wide mouth HDPE bottle or 4-ounce clear PVC cylinder bottle; supplied with caps.

2.06 SOURCE QUALITY CONTROL

A. Test Requirements: Perform tests for each batch of epoxy resin.

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B. Pot Life Test:

1. Condition Component A and Component B to required temperature.
2. Measure components in ratio of Component B as stated on manufacturer's label into an 8-fluid ounce paper cup.
3. Mix components for 60 seconds using non-metallic stirring instrument. Scrape sides and bottom of cup periodically.
4. Probe mixture once with non-metallic stirring instrument every 30 seconds, starting 2 minutes prior to minimum specified pot life.
5. Pot Life Definition: Time at which a soft stringy mass forms in center of cup.

C. Slant Shear Test: Prepare specimens and perform tests in accordance with ASTM C882.

PART 3 EXECUTION

3.01 GENERAL

A. Unless permitted otherwise, structurally repair cracks listed below:

1. Cracks considered to be defective as defined in Section 03 30 00, Cast-in-Place Concrete.
2. All vertical cracks near corners or intersections.
3. All horizontal cracks at wall bases.
4. All cracks in walls of circular tanks.
5. All cracks caused by voids or honeycombs.
6. All cracks caused by construction overloading.
7. All vertical or diagonal cracks caused by drying shrinkage within a distance equal to the height of wall from the face of corners or intersecting walls. Inject 90 days after placement, unless approved otherwise by the project Structural Engineer.
8. All horizontal cracks caused by drying shrinkage within a distance equal to one-quarter on the wall height above or below elevated slabs. Inject 90 days after placement, unless approved otherwise by the project Structural Engineer.
9. All cracks as a result of thermal shrinkage where the concrete member being injected has been allowed to dry after placement for a minimum of 90 days.

B. Do not proceed with injection work until submittals have been reviewed and approved by Engineer.

C. Perform crack injection work after removing defective surface materials and after performing surface preparation, but prior to applying surface repair material unless otherwise noted. See Section 03 01 32, Repair of Vertical and

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Overhead Concrete Surfaces, Section 03 01 33, Repair of Horizontal Concrete Surfaces, for concrete surface repair system.

D. Width of cracks may vary along length and through thickness of concrete section.

E. Remove all excess, unused epoxy resin materials on concrete surfaces exposed to view prior to end of Work.

3.02 EQUIPMENT

A. Portable, positive displacement type pumps with in-line metering to meter and mix two epoxy resin components and inject mixture into cracks or joints.

B. Pumps:

1. Electric or air powered with interlocks providing positive ratio control of proportions for the two components at nozzle.
2. Primary injection pumps for each material of different mix ratio, including a standby backup pump of similar ratio.
3. Capable of immediate compensation for changes in resins.
4. Do not use batch mix pumps.

C. Discharge Pressure: Automatic pressure controls capable of discharging mixed epoxy resin at pressures in accordance with epoxy resin manufacturer's printed instruction and able to maintain pressure.

D. Automatic Shutoff Control: Provide sensors on both Component A and Component B reservoirs for stopping machine automatically when only one component is being pumped to mixing head.

E. Proportioning Ratio Tolerance: Maintain epoxy resin manufacturer's prescribed mix ratio within a tolerance of plus or minus 5 percent by volume at discharge pressure up to 160 psi.

F. Ratio/Pressure Check Device:

1. Two independent valve nozzles capable of controlling flow rate and pressure by opening or closing valve to restrict material flow.
2. Pressure gauge capable of sensing pressure behind each valve.

3.03 PREPARATION

A. Free cracks from loose matter, dirt, laitance, oil, grease, efflorescence, salt, and other contaminants.

B. Clean cracks in accordance with epoxy resin manufacturer's instructions.

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C. Clean surfaces adjacent to cracks from dirt, dust, grease, oil, efflorescence, and other foreign matter detrimental to bond of surface seal system and to expose the full extent of cracks and joints in accordance with manufacturer's printed instruction.

D. Do not use acids and corrosives for cleaning, other than those specified herein unless neutralized prior to injecting epoxy resin.

E. During installation and curing of materials, if ambient temperature is expected to drop below manufacturer's recommended minimum temperature, provide enclosures and heat as required.

F. Provide work platforms as required.

G. Dry out cracks or joints if required by manufacturer's instructions.

3.04 APPLICATION

A. All liquid is to be removed from hydraulic structure prior to commencing with epoxy injection, unless approved otherwise.

B. Entry Ports:

1. Establish openings for epoxy resin entry in surface seal along crack.
2. Determine space between entry ports equal to thickness of concrete member to allow epoxy resin to penetrate to the full thickness of the member.
3. Drill injection holes at an angle between 45 degrees and 60 degrees from surface of concrete and perpendicular to alignment of cracks, to intersect crack at midpoint of concrete section, except as noted otherwise.
4. Locate drill holes on alternate sides of crack where possible, unless orientation of crack is known or has been verified by non-destructive testing techniques or core drilling.
5. Drill Hole Spacing: Do not to exceed concrete thicknesses or 12 inches maximum, except as noted otherwise.
6. Take measures to prevent drilling holes for injection too shallow or too deep, or damaging existing waterstop in joints.
7. Remove dust and debris in drill holes and on surface of structure resulting from drilling operation, by flushing with water prior to installing the injection packers or ports.
8. Space entry ports closer together to allow adjustment of injection pressure to obtain minimum loss of epoxy to soil at locations where:
    a. Cracks or joints extend entirely through concrete element.
    b. Backfill of walls on one side.
    c. Slab-on-grade.
    d. Difficult to excavate behind wall to seal both surfaces of crack.

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9. Install injection packers or ports in drill holes in accordance with manufacturer's printed instructions with zerk coupling or other one-way ball or check valve, to permit testing for watertightness and acid flushing of cracks.

C. Acid Flushing of Cracks:

1. Flush cracks with acid flushing solution in accordance with manufacturer's printed instructions. Apply acid flushing solution for a sufficient duration to permit solution to penetrate full depth and length of cracks.
2. Following acid flushing, flush cracks with copious quantities of potable water in accordance with manufacturer's printed instructions until no evidence of acid flushing solution is visible in flush water.
3. Submit in-field health and safety plan for acid flushing operation. As a minimum, identify worker conducting acid flushing by wearing a reflective safety vest and signs indicating "Acid Flushing". Also, clearly identify Work area where acid flushing is underway by signs and isolate by placing orange pylons or other temporary barrier, and signs indicating "Acid Flushing". As work progresses, move pylons or barriers and signs to maintain a safe zone.

D. Application of Surface Seal along Cracks:

1. Apply surface seal in accordance with manufacturer's instructions to designated cracks face prior to injection. Seal surface of cracks to contain and prevent escape of injection epoxy.
2. Cure surface seal in accordance with manufacturer's printed instructions before commencing inject work.

E. Epoxy Injection:

1. Ensure zerk coupling is not installed in ports or packers next to the one being injected.
2. Start injection into each crack at lowest elevation entry port or packer along vertical or diagonal crack, and at one end of horizontal crack.
3. Where injection entry ports or packers are used, continue injection at first port or packer until resin begins to flow out of port or packer at next highest elevation. Plug first port or packer and start injection at second port or packer until resin flows from next port or packer.
4. Inject entire crack with same sequence.
5. At no time inject more than 6 feet length of first vertical crack before verifying resin in sample bottle has start to set and cure.
6. Prior to commencing injection work along a horizontal crack in structure when processed using ports or packers with zerk couplings are used, remove zerk couplings from injection ports or packers except for

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two ports or packers located where injection work will commence. Commence injection work in first two ports or packers. Once clean resin is vented from third injection port or packer, cease injection at first port or packer, and install zerk coupling and commence injection at third port or packer. Repeat process for fourth and subsequent ports or packers until full length of crack has been injected.

F. Finishing:

1. Allow epoxy resin to cure in accordance with manufacturer's instruction after cracks have been completely injected to allow surface seal removal without draining or runback of uncured epoxy resin material from cracks.
2. Remove surface seal and injection packers or ports from cured injection resin along crack.
3. Finish crack faces flush with adjacent concrete.
4. Indentations or protrusions caused by placement of entry ports, packers, drill holes, or damage from removal of surface seal is not acceptable.
5. Grind off protrusions and patch indentations and holes from injection packers and entry ports with a suitable patch material to satisfaction of Engineer.
6. Remove surplus surface seal material splatters and injection resin material runs and spills from concrete surfaces.

3.05 FIELD QUALITY CONTROL

A. Epoxy Resin Two Component Ratio Tests:

1. Disconnect mixing head and pump two resin components simultaneously through ratio check device.
2. Adjust discharge pressure to 160 psi for both resin components.
3. Simultaneously discharge both resin components into separate calibrated containers.
4. Compare amounts simultaneously discharged into calibrated containers during same time period to determine mix ratio.
5. Complete test at 160 psi discharge pressure and repeat procedure for 0 psi discharge pressure.
6. Run ratio test for each injection unit at beginning and end of each injection work day, and when injection work has stopped for more than 1 hour.
7. Document and maintain complete accurate records of ratios and pressure checks.

B. Injection Pressure Test:

1. Disconnect mixing head of injection equipment and connect two resin component delivery lines to pressure check device.

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2. Pressure Check Device:
    a. Two independent valved nozzles capable of controlling flow rate and pressure by opening or closing of valve.
    b. Pressure gauge capable of sensing pressure buildup behind each valve.
3. Close valves on pressure check device and operate equipment until gauge pressure on each line reads 160 psi.
4. Stop pumps and observe pressure; do not allow pressure gauge to drop below 150 psi within 3 minutes.
5. Run pressure test for each injection equipment unit:
    a. Beginning and end of each injection work day.
    b. When injection work stop for more than 45 minutes.
6. Check tolerance to verify equipment capable of meeting specified ratio tolerance.

C. Bottled Sample Tests:

1. During injection operation, provide at least one sample of mixed epoxy resin for each injection pump per shift per injection work day in a sample bottle.
2. Provide sufficient sample to demonstrate sample material epoxy resin will set and cure correctly.
3. Label each bottled sample with Contractor's name, date, and time sample was taken, and location in structure where sample was taken. Record details of bottle sample tests.
4. Place filled sample bottle upright in a container and allow sample to cure.
5. After sample has been allowed to cure, cut bottled sample open and visually inspect contents to verify that epoxy resin material has completely reacted and cured.
6. Evaluation and Assessment of Test:
    a. Should bottled sample(s) indicate a problem; such as epoxy resin not cured or foreign liquid in sample bottle, take verifying core sample immediately from cracks, where material was used.
    b. Should above-referenced bottle sample(s) and core sample(s) indicate a problem with epoxy resin, arrange to have a Technical Representative of the epoxy resin manufacturer come to Site to review bottled sample(s) and core drilled sample(s) with Engineer and provide technical advice on corrective measures.
    c. Carry out further investigation work or corrective measures recommended by Technical Representative of epoxy resin manufacturer.

END OF SECTION

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SECTION 04 22 00
CONCRETE UNIT MASONRY

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   a. A82/A82M, Standard Specification for Steel Wire, Plain, for Concrete Reinforcement.
   b. A153/A153M, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
   c. C33, Standard Specification for Concrete Aggregates.
   d. C90, Standard Specification for Loadbearing Concrete Masonry Units.
   e. C140, Standard Test Methods for Sampling and Testing Concrete Masonry Units and Related Units.
   f. C144, Standard Specification for Aggregate for Masonry Mortar.
   g. C150, Standard Specification for Portland Cement.
   h. C207, Standard Specification for Hydrated Lime for Masonry Purposes.
   i. C270, Standard Specification for Mortar for Unit Masonry.
   j. C404, Standard Specification for Aggregates for Masonry Grout.
   k. C476, Standard Specification for Grout for Masonry.
   l. C618 12 Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete.
   m. C744, Standard Specification for Prefaced Concrete and Calcium Silicate Masonry Units.
   n. C979, Pigments for Integrally Colored Concrete.
   o. C989, Standard Specification for Ground Granulated Blast-Furnace Slag for Use in Concrete and Mortars.
   p. C1314, Standard Test Method for Compressive Strength of Masonry Prisms.
   q. C1403, Standard Test Method for Rate of Water Absorption of Masonry Mortars.
   r. **[A: C1611/C1611M, Standard Test Method for Slump Flow of Self-Consolidating Concrete.]**
   s. E514/E514M, Standard Test Method for Water Penetration and Leakage through Masonry.
2. The Masonry Society (TMS):
   a. TMS 402/ACI 530/ASCE 5; Building Code Requirements for Masonry Structures and Companion Commentaries. (MSJC Code and Commentary).

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b. TMS 602/ACI530.1/ASCE6; Specification for Masonry Structures.
c. 602/American Concrete Institute ACI 530.1/ASCE 6, Specification for Masonry Structures and Companion Commentaries. (Masonry Standards Joint Committee Specifications and Commentary).

3. International Code Council (ICC):
   a. International Building Code (IBC).
   b. ICC Evaluation Service (ICC-ES) Reports.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings.
2. Data Sheets:
   a. Horizontal joint reinforcement.
   b. Preformed control joint materials.
   c. Water repellant masonry sealer.
   d. Grout mix design.
   e. Mortar mix design or prebagged mortar properties and data sheets.
   f. Grout sand gradation in accordance with ASTM C404.

B. Informational Submittals:

1. Method and Location of Placing Grout: High lift or low lift.
2. Mix design test results.
3. Certifications:
   a. Units comply with ASTM C55 and ASTM C90.
   b. Grout test results conform to ASTM C1019.
   c. Grout aggregates conform to requirements of ASTM C33, including nonreactivity.
   d. Mortar sand conform to requirements of ASTM C144.
4. Test results of Project samples from masonry unit manufacturer stating that units comply with ASTM C90. Documentation of material testing shall be one less than 1 year old.
5. Test results of proposed grout mix deign stating that units comply with ASTM C1019. Documentation of material testing shall be 1 year old or less.
6. Test reports stating aggregates for mortar meet requirements of ASTM C144.
7. Test reports or letter of certification stating aggregates for grout meet requirements of ASTM C404.
8. Method and materials for removal of efflorescence.
9. Field test results to qualify materials: Grout tests in accordance with ASTM C1019.

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1.03 QUALITY ASSURANCE

A. Mockups:

1. Lay up Sample panel for each type of masonry at Site.
2. Dimensions: Minimum 4 feet high by 4 feet long.
3. Use approved materials and procedures.
4. May be part of permanent construction.
5. Approved panels shall serve as basis of color, texture, bond, quality of finished joints, surface applied finishes, and for acceptance of permanent construction.
6. Demonstrate ability to keep grout isolated and in certain cells during any sequence of placement, and to demonstrate materials will be restricted to cells and bond beams intended to receive grout.
7. Construction shall show areas required to receive mortar, including webs on each side of each grouted cell to prevent grout from entering adjacent cells or courses.
8. Where bond beams are to be used, demonstrate proper placement of grout to bond beam level, and proper placement of bond beam prior to placement of grout above bond beam level.
9. Demonstrate proper use of running bond.
10. Compliance Requirements: For masonry finish and appearance, dimension tolerances, tolerances of construction, joint tolerances, and wall plumb tolerances, comply with the requirements and criteria of NCMA, ASTM C90, and TMS 602.1.

B. Preinstallation Conference:

1. Required Meeting Attendees:
   a. Masonry subcontractor, including masonry foreman.
   b. Ready-mix producer.
   c. Admixture representative.
   d. Testing and sampling personnel.
   e. Design Structural Engineer or Engineer’s representative.
   f. Project Architect for coating system and appearance.
2. Schedule and conduct prior to start of masonry construction.
3. Notify Engineer of location and time.
4. Agenda shall include:
   a. High lift and low lift procedures.
   b. Mortar, grout, unit, and reinforcing submittals.
   c. Types and locations of rebar splices.
   d. Joint tooling.
   e. Admixture types, dosage, performance, and redosing at Site.
   f. Mix designs and test of mix.
   g. Placement methods, techniques, equipment, consolidation, and reconsolidation.

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h. Protection procedures for environmental conditions.
i. Other specified requirements requiring coordination.

5. Submit conference minutes as specified in Section 01 31 19, Project Meetings.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Storage and Protection: Keep units and mortar/grout cementitious ingredients, including lime, dry.

PART 2 PRODUCTS

2.01 COMPRESSIVE STRENGTH OF MASONRY ASSEMBLAGE

A. Minimum 28-Day Specified Compressive Strength (f'm) of Masonry: 2,000 psi.

2.02 CONCRETE MASONRY UNITS (CMU)

A. ASTM C90: Normalweight.

1. Net Area Compressive Strength: 2,800 psiminimum, in accordance with TMS 602, Table 2.
   a. Water Repellent Admixture:
      1) Structural concrete masonry units in weather exposed exterior wall shall be manufactured with integral liquid polymeric admixture to provide resistance to water penetration.
      2) Manufacturers and Products:
         a) W.R. Grace & Co.; Dry-Block Block Admixture.
         b) BASF Construction Chemicals; Rheopel Plus.
2. Nominal Size: 16 inches long by 8 inches high by thickness shown on Drawings.
3. Color of Units: Natural.
4. Surface Texture on Exposed Surfaces: Smooth.
5. Surface Texture: Smooth on interior, concealed exterior, and surface 1 foot below finished grade.

B. General Concrete Masonry Unit (CMU) Requirements:

1. Furnish or cut special shapes for corners, jambs, lintels, and other areas shown or required.
2. Special units shall match color and texture of standard units.
3. Where units are placed so end of unit is exposed, such as at a corner or intersection, exposed end of that block shall have surface to match color and texture of sides of other units.

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4. Furnish sound, dry, clean units free of cracks, prior to placing in structure.
5. Vertical Cells to be Grouted: Capable of alignment sufficient to maintain clear, unobstructed continuous vertical cell dimensions in accordance with TMS 602, Table 7.
6. Masonry unit size and shape shall allow for all placement patterns. Use vertical grout dams to prevent materials, such as grout or poured insulation, from escaping from cell being filled to adjacent cells where material is not intended to be placed.

2.03 MORTAR MATERIALS

A. Portland Cement-Lime Mortar:

1. ASTM C270.
2. Cement: ASTM C150, **[A: Type I] [B: and] [C: Type II]** portland cement.
3. Lime: ASTM C207, Type S hydrated.
4. Aggregates:
   a. Non-reactive in accordance with ASTM C33, Appendix X1.
   b. Mortar: ASTM C144, sand.

B. **[A: Mortar Cement Mortar: ASTM C1329.]**

C. **[A: Masonry Cement Mortar: ASTM C91.]**

D. Water: Fresh, clean, and potable.

E. **[A: Water Repellent Admixture:**

1. **ASTM C1403.**
2. **Mortar for [B: structural] [C: and] [D: textured] concrete masonry units in weather exposed exterior walls shall include an integral liquid polymeric admixture to provide resistance to water penetration.]**
3. **Manufacturer and Product: BASF Construction Chemicals; Rheopel Plus Mortar Admixture]**.

F. Manufacturers and Products:

1. W.R. Grace; DRY-BLOCK.
2. Harris Specialty Chemicals.
3. Axim Italcementi Group; Intrapel.
4. BASF Chemical Co.; Rheopel Admixture.

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G. Mortar Color Admixture:

1. Meet the requirements of ASTM C979.
2. Manufacturer and Product: Davis Colors, Los Angeles, CA; True Tone Mortar Color.
3. Color shall be **[A: as shown on Finish Schedule.] [B: as shown on Drawings.] [C: selected by Engineer.] [D: selected by Architect.]**

2.04 GROUT MATERIALS

A. Cement: ASTM C150, **[A: Type I] [B: and] [C: Type II]** portland cement.

B. Fly Ash: Fly Ash (Pozzolan): Class F **[A: and Class C]** fly ash in accordance with ASTM C618.

C. Slag Cement: In accordance with ASTM C989, Grade 100 or Grade 120.

D. Lime: ASTM C207, Type S hydrated.

E. Aggregates:

1. ASTM C404, fine and coarse.
2. Non-reactive in accordance with ASTM C33, Appendix X1.

F. Water: Fresh, clean, and potable.

2.05 REINFORCEMENT

A. Reinforcement: Clean and free from loose rust, scale, and coatings that reduce bond.

B. Deformed Bars: As specified in Section 03 21 00, Steel Reinforcement.

C. **[A: Horizontal Joint Reinforcement:**

1. **Two parallel, ASTM A82/A82M, No. 9 wires, galvanized in accordance with ASTM A153/A153M, weld connected to No. 9 [B: perpendicular] [C: or] [D: diagonal] cross wire at 16 inches, maximum, center.**
2. **Furnish special manufactured corner and wall intersection pieces.**
3. **Manufacturer: Dayton Superior/Dur-O-Wal, Dayton, OH.]**

2.06 PREFORMED CONTROL JOINTS

A. Solid rubber cross-shape extrusions as manufactured by:

1. Dayton Superior/Dur-O-WalDayton, OH; DA 2001 Control Joint Regular Rubber.

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2. Hohmann and Barnard, Inc, Hauppauge, NY; #RS-Standard.

2.07 MORTAR MIXES

A. In accordance with ASTM C270, Type S and MSJC Specifications.

B. Mix Method:

1. Property Method: Minimum average mortar 28-day compressive strength **[A: 1,800 psi] [B:]**.
2. **[C: Proportion Method: Proportion per Table 1 of ASTM C270.]**

C. Mixing:

1. Machine mix in approved mixers in accordance with ASTM C270. **[A: Time addition of approved admixtures in accordance with manufacturer's instructions. Procedure used for adding it to mix shall provide good dispersion.]**
2. **[B: Follow manufacturer's instructions for mortar color admixture.]**
3. **[C: Follow manufacturer's instructions for water repellent admixture.]**
4. **[D: Review compatibility with other mortar admixture.]**

D. **[A: Where colored masonry units are used, color mortar to match. Inert coloring pigments may be added, but shall not exceed 6 percent by weight of cement.]**

2.08 GROUT MIXES

A. **[A: Compressive Strength Property:**

1. **Minimum [B: 2,000 psi] [C:] at 28 days. Grout strength shall not exceed two times the minimum specified strength.**
2. **[D: Proportions: Conform to ASTM C476, Table 1]]**.

B. Mix Design:

1. Proportions:
   a. Design mix to meet **[A: property/strength] [B: proportion]** requirements.
   b. **[C: Where fly ash or slag is included in mix, fly ash or slag content shall be a minimum of 25 percent and a maximum of [D: 25] [E: 40] [F:] percent of weight of total cementitious materials.]**
2. Slump: 8-inch minimum, 11-inch maximum.

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C. Mixing:

1. Do not use water reducers, air entrainment, plasticizing, high-range water reducers, or other non-specified admixtures in grout mixes.
2. Transit-Mixed Grout: Meet requirements of ASTM C476.
3. For high lift grouting, add approved grout expansion admixture in accordance with manufacturer's recommendations.
4. Fluid consistency suitable for placing without segregation with a slump of 8 inches to 11 inches.

2.09 WATER REPELLENT MASONRY SEALER

A. Characteristics:

1. Water-based blend of silanes and siloxanes.
2. VOC compliant.

B. Performance Requirements:

1. Water Absorption: 95 percent reduction in weight gain when tested in accordance with ASTM C140.
2. Water Repellency: 99 percent reduction in weight gain when tested in accordance with ASTM E514.

C. Manufacturers and Products:

1. W. R. Grace & Co.; Infiniseal DB Sealer.
2. BASF Construction Chemicals; Enviroseal PBT.

PART 3 EXECUTION

3.01 GENERAL

A. Meet requirements of **[A: 2003] [B: 2006] [C: 2009]** IBC, Chapter 21 and **[D: 2002] [E: 2005] [F: 2008]** The Masonry Society (TMS) 602/American Concrete Institute (ACI)530.1/ASCE 6, Specification for Masonry Structures and Companion Commentaries (MSJC), Part 3, Execution, except as modified in this section.

B. Moisture Protection:

1. Keep units dry while stored on Site.
2. Do not wet units prior to laying.

C. Provide measures to prevent moisture from entering incomplete walls and open cells.

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D. Cold Weather: Meet requirements of MSJC Specification Section “Cold Weather Construction”.

E. Hot Weather: Meet requirements of MSJC Specification Section “Hot Weather Construction”.

F. After construction during cold weather, maintain newly constructed masonry temperature above 32 degrees F for a minimum of 24 hours using MSJC or other approved cold weather methods.

G. After construction and during hot weather, fog spray newly constructed masonry in accordance with MSJC hot weather construction requirements.

3.02 PREPARATION

A. Concrete Foundations: Meet tolerance requirements of ACI 117 prior to starting any masonry work.

B. Prepare surface contact area of foundation concrete for initial mortar placement by removing laitance, loose aggregate, and other materials, and anything that would prevent mortar from bonding to foundation.

C. Patch or grind out-of-tolerance foundation surfaces to receive mortar prior to starting masonry work.

D. Clean reinforcement dowels and projecting embeds by removing laitance, spillage, or items that will adversely affect grout bond.

E. Prevent surface damage to foundation concrete that will be exposed to view outside of contact area.

3.03 LAYING MASONRY UNITS

A. General:

1. Finish Tolerances (Measured on Interior Surfaces): Meet requirements of “Site Tolerance” requirements of Part 3, Execution, of the MSJC Specifications.
2. Place units with chipped edges or corners such that chipped area is not exposed to view.

B. Wall Units:

1. General:
   a. If necessary to move a unit after once set in-place, remove from wall, clean, and set in fresh mortar.
   b. Toothing of masonry units is not permitted.

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2. Running Bond:
    a. Unless otherwise shown, lay up walls in straight, level, and uniform courses using a running bond pattern.
    b. Place units for continuous vertical cells and mortar joints to prevent materials, such as grout **[A: and poured insulation]**, from escaping from cell being filled to adjacent cells where material is not intended to be placed.
    c. Corners: Lay standard masonry bond for overlapping units and grout solid.
    d. Intersecting Walls: Half unit appearance shall not extend and be visible on exterior side of intersecting wall. Provide hooked corner bars in bond beam units **[B: and joint reinforcement]** as shown on Drawings.
3. Stack Bond: Provide only where specifically indicated on Drawings. Lay up **[C: walls] [D: open end units]** in straight, uniform courses with vertical joints aligned and plumb.
4. Glazed Concrete Masonry Units:
    a. Single-faced units may be installed through wall where walls or partitions are shown to have glazed masonry unit finish on one side only.
    b. Use facing for dimensional and plane reference in installation.
    c. Where glazed masonry unit finish is indicated on both sides of a wall or partition, install coved bases of two-unit construction or two-faced units through the wall.
    d. Install coved bases flush with finished surfaces above, except as otherwise specified.
5. Special Shapes:
    a. Provide and place such special units as corner block, doorjamb block, lintel block fillers, and similar blocks as may be required.
    b. Use required shapes and sizes to work to corners and openings, maintaining proper bond throughout wall.

3.04 BUILT-IN ITEMS

A. Position door frames, windows, vents, louvers, and other items to be built in wall, and construct wall around them.

B. Install masonry anchors to secure items to wall.

C. Fill spaces around items with grout except use mortar at mortar joints.

D. Do not place electrical, instrumentation, or water conduits in a cell containing parallel reinforcement, unless approved in writing by Engineer. Additionally, pipes, sleeves, and conduits shall meet requirements of TMS 402/ACI 530/ASCE 5, Building Code Requirements for Masonry Structures (MSJC Code) and MSJC specification construction requirements.

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3.05 MORTAR JOINTS

A. General:

1. Meet masonry erection requirements of MSJC, Part 3, Execution, 3.3B.
2. As units are laid, remove excess mortar from grout space of cells to be filled. Final grout space, including any remaining mortar projections, shall be as required by MSJC Table "Grout Space Requirements".
3. Place mortar before initial setting of cement takes place. Retemper only as required for it to remain plastic. Retempering of colored mortar is not allowed.
4. **[A: Remove mortar containing water repellent admixture from face of masonry before it sets.]**

B. Exposed Joints:

1. Tool joints exposed to view after final construction, unless otherwise noted or shown.
2. Cut joints flush and as mortar takes its initial set; tool to provide a **[A: concave] [B:]** joint.
3. Perform tooling with tool that compacts mortar, pressing excess mortar out.
4. Perform tooling when mortar is partially set, but still sufficiently plastic to bond rather than dragging it out.
5. Rake out joints that are not tight at time of tooling, point, and then tool.
6. Rake and tool joints at split-face surfaces, interior and exterior.

C. Concealed Joints: Strike flush with no further treatment required.

D. **[A: Glazed Concrete Masonry Units:**

1. **Rake mortar from joints to depth of 1/4 inch.**
2. **Fill joints flush with glazed surface using [B: Type 1, silicone, sealant as specified in Section 07 92 00, Joint Sealants,] [C: latex portland cement grout as specified in Section 09 30 00, Tiling,] color as selected.**
3. **Tool joints slightly concave.]**

3.06 CONTROL JOINTS

A. Preformed Control Joints:

1. Omit mortar from vertical joints.
2. Place in units fabricated to receive rubber control joint material as wall is built.

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3. After wall is grouted, cured, and cleaned, install backing rod and sealant as specified in Section 07 92 00, Joint Sealants.
4. Place and tool sealant to match depth of typical joint.

3.07 REINFORCING

A. Foundation Dowels:

1. Locate first foundation dowel at end of wall in center of first cell; typically 4 inches from end of wall.
2. Locate at each side of control joints and openings and below beam and joist seats, and then locate at maximum required spacing between these bars.
3. Size, number, and location of foundation dowels shall match all typical and additional vertical wall reinforcing, unless otherwise noted.
4. When foundation dowel does not line up with vertical core, do not slope more than 1 horizontal to 6 vertical to bring it into alignment.

B. Vertical Reinforcing:

1. Use deformed bars.
2. Hold in position near ends of bars by wire ties to dowels or by reinforcing positioners.
3. For high lift grouting, hold in position at maximum intervals of **[A: 160] [B: 180] [C: 200]** bar diameters by reinforcing positioners.
4. Lap reinforcing bars as shown or approved.
5. Wire tie splices together.
6. Minimum Bar Clearance: 1/2-inch from masonry for coarse grout **[D: 1/4-inch from masonry for fine grout]**, from formed surfaces, and from parallel bars in same grout space.

C. Horizontal Reinforcing:

1. Use deformed bars.
2. Lay on webs of bond beam units and place as wall is built. Increase web depth to ensure 1/2-inch cover over top of rebar.
3. Lap reinforcing bars where spliced and wire tie together.
4. Minimum Bar Clearance: 1/2 inch from masonry for coarse grout **[A: 1/4 inch from masonry for fine grout]**, from formed surfaces, and from parallel bars in same grout space.
5. Terminate reinforcing bars 2 inches clear from control joints except horizontal bars at roof and floor courses shall be continuous through joints.

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D. **[A: Horizontal Joint Reinforcement:**

1. **Use where indicated on Drawings.**
2. **[B: Provide in addition to typical, deformed horizontal reinforcing steel.]**
3. **Space maximum [C: 16] [D: 24] inches apart, vertically.**
4. **Lap ends 16 inches minimum.**
5. **Terminate reinforcing 2 inches clear from control joints except reinforcement at roof and floor courses shall be continuous through joints.**
6. **Use manufactured corner and other wall intersection pieces.]**

3.08 MORTAR PRODUCTION

A. Mix bulk materials in accordance with MSJC Specification.

B. Mix prebagged materials with water to produce a workable consistency.

C. Remix or retemper to maintain workability. Discard mortar that has begun to stiffen or is not used within 2-1/2 hours after initial mixing.

3.09 GROUT PLACEMENT

A. Do not mix, convey, or place with equipment constructed of aluminum.

B. Secure vertical and horizontal reinforcement, ties, bolts, anchors, and other required embedments in place; inspect and verify before placing grout.

C. Grout beams over openings in one continuous operation.

D. Maintain vertical alignment in accordance with **[A: ACI 530.1, Table 7] [B: UBC Table 21-C]**:

1. Place grout within 1-1/2 hours of addition of water to mix.
2. Use reinforcing positioners to secure vertical reinforcement.

E. Grouting Requirements:

1. **[A: Solid grout all walls.] [B: Partial grout all walls as shown.]**
2. **[C: For multi-wythe construction, space vertical grout barriers maximum 30 feet horizontally, extending full height of wall.] [D:]**
   a. Slump: 8 inches to 11 inches.
   b. Do not start grouting until wall mortar has cured for 24 hours, minimum.
3. Fully embed horizontal steel with grout in an uninterrupted pour.
4. Do not construct wall more than one course above top of grout pour prior to placing grout.

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5. Partial Grouting Requirements:
    a. Fill cells containing reinforcing steel, anchor bolts, and other embedded items as shown with grout.
    b. Construct cells to be filled to confine grout within cell.
    c. Cover tops of unfilled vertical cells under a bond beam with metal lath to confine grout fill to bond beam section.
    d. Form horizontal construction joints between pours by stopping grout pour 1-1/2 inches below a mortar joint, except at a bond beam; stop pour 1/2 inch below top of masonry unit.

F. **[A: Partial Grouting with Insulation Fill:**

1. **Where cells of masonry units are to receive masonry fill insulation in some cells and to receive grout in some cells, provide continuous mortar on block webs on each side of cells to be filled with grout to ensure insulation will not enter grout cells.**
2. **Where bond beams are required with masonry fill insulation and grout, limit pours to less than 6 feet in height.]**

G. Vibration:

1. Use internal “pencil” type, low energy vibrator to thoroughly consolidate grout and reduce amount of air voids. Do not use concrete vibrators.
2. After initial water loss and settlement has occurred, but before it has taken any set, reconsolidate grout.
3. Waiting period for reconsolidation will vary depending upon weather conditions and block absorption rates, but under “normal” weather conditions with average masonry units the waiting period should be between 30 minutes and 60 minutes.

H. Cleanouts:

1. Construct in accordance with MSJC specification.
2. Provide for grout pours heights over **[A: 5 feet in accordance with the 2009 IBC] [B: 5 feet 4 inches in accordance with the 2012 IBC]**.
3. Provide of sufficient size to permit cleaning of cell, positioning of reinforcing, and inspection at bottom of every vertical cell containing reinforcing and maximum of 32 inches on center.
4. Location: Concealed from view after final construction, unless otherwise approved by Engineer.
5. After wall has been inspected and approved and prior to grouting, cap cleanouts in a manner that will seal them from grout leakage and provide a flush finish.

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3.10 WATER REPELLENT MASONRY SEALER

A. Remove efflorescence prior to applying water repellents. Dispose of waste generated.

B. Apply to exposed exterior concrete masonry walls.

C. Repoint loose, cracked, or disintegrating mortar at least 7 days prior to application. Ensure joint sealants and caulking are fully cured and wall surfaces are clean, dry, and free of chemical cleaners, efflorescence, dirt, oils, mortar smears, and other surface contaminants.

D. Follow manufacturer's recommendations for weather conditions during application.

E. Test a 5-foot by 5-foot wall area to ensure proper coverage, desired water repellency properties, and desired surface appearance when sealer is fully dried.

F. Apply with spray, brush, or roller following manufacturer's recommendations, at a coverage rate of 50 square feet to 150 square feet per gallon, as determined by testing. Use two-coat application where recommended by manufacturer.

3.11 FIELD QUALITY CONTROL

A. Owner-Furnished Quality Assurance, in accordance with IBC Chapter 17 requirements, is provided in the Statement of Special Inspections Plan **[A: on Drawings] [B: in Supplement located at end of Section 01 45 33, Special Inspection, Observation, and Testing]**. Contractor responsibilities and related information are included in Section 01 45 33, Special Inspection, Observation, and Testing.

B. Contractor-Furnished Quality Control: Inspection and testing as required in Section 01 45 16.13, Contractor Quality Control.

C. Masonry shall be tested by **[A: independent testing agency, retained by Contractor and approved by Engineer] [B: testing agency retained by Owner]**.

D. Provide adequate facilities for safe storage and proper curing of masonry prisms, mortar samples, and grout samples, as applicable, onsite for first 24 hours, and for additional time as may be required before transporting to test lab.

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E. Masonry Testing:

1. Masonry strength shall be determined using **[A: unit strength method] [B: prism testing]** as shown.
2. Masonry test prisms, when required or desired, shall be constructed onsite with same materials and workmanship to be used for Project and in accordance with **[C: ASTM C1314] [D: UBC Standard 21-17]**. Method and frequency of prism testing shall be as shown on the Special Inspection and Testing Plan.
3. **[E: Unit Strength Method:**
   a. **Method and frequency for mortar, grout, and masonry unit sampling and testing shall be as shown.**
   b. **Provide masonry units for test samples required.]**

F. Corrective Action:

1. If compressive strength tests made prior to construction of permanent structure fail to meet Specifications, adjustments shall be made to mix designs for mortar, or grout, or both, as needed to produce specified strength.
2. If strength tests performed on materials representative of in-place construction fail to meet Specifications, prisms or cores shall be cut from constructed walls in sufficient locations to adequately determine strength in accordance with **[A: MSJC] [B: IBC 2105.3]**.
3. **[C: Water Repellent Performance Test: Masonry using concrete masonry units and mortar with integral water repellent additives, and water repellent masonry sealer, shall achieve a Class E rating when evaluated in accordance with ASTM E514, with the test extended to 72 hours.]**

3.12 CLEANING

A. Immediately after completion of grouting, clean masonry surfaces of excess mortar, grout spillage, scum, stains, dirt, and other foreign substances using clean water and fiber brushes.

B. Clean walls not requiring painting or sealing so there are no visible stains.

3.13 PROTECTION OF INSTALLED WORK

A. Do not allow grout and mortar stains to dry on face of exposed masonry.

B. Protect tops of walls at all times. Cover tops of walls with waterproof paper when rain or snow is imminent and when the Work is discontinued.

C. Adequately brace walls until walls and roof are completed.

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D. Provide sufficient bracing to protect walls against damage from elements, including wind and snow.

E. Protect masonry against freezing for minimum 72 hours after being laid.

F. Protect masonry from damage until final acceptance of the Work. Damaged units will not be accepted.

END OF SECTION

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SECTION 05 05 19
POST-INSTALLED ANCHORS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Concrete Institute (ACI):
   a. 318, Building Code Requirements for Structural Concrete.
   b. 355.2, Qualification of Post-Installed Mechanical Anchors in Concrete.
   c. 355.4, Qualification of Post-Installed Adhesive Anchors in Concrete.
2. American Iron and Steel Institute (AISI): Stainless Steel Type 316.
3. American National Standards Institute (ANSI).
4. ASTM International (ASTM):
   a. A123/A123M, Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   b. A143, Practice for Safeguarding Against Embrittlement of Hot-Dip Galvanized Structural Steel Products and Procedure for Detecting Embrittlement.
   c. A153/A153M, Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
   d. A193/A193M, Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service.
   e. A194/A194M, Specification for Carbon and Alloy Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both.
   f. A380, Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.
   g. A385, Practice for Providing High-Quality Zinc Coatings (Hot-Dip).
   h. A563, Specification for Carbon and Alloy Steel Nuts.
   i. A780, Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings.
   j. A967, Specification for Chemical Passivation Treatments for Stainless Steel Parts.
   k. E488, Standard Test Methods for Strength of Anchors in Concrete Elements.
   l. F436, Specification for Hardened Steel Washers.
   m. F468, Specification for Nonferrous Bolts, Hex Cap Screws, and Studs for General Use.
   n. F568M, Specification for Carbon and Alloy Steel Externally Threaded Metric Fasteners.

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o. F593, Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
p. F594, Specification for Stainless Steel Nuts.
q. F1554, Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength.

5. International Association of Plumbing and Mechanical Officials Uniform ES (IAPMO-UES): Evaluation Reports for Concrete and Masonry Anchors.
6. International Code Council Evaluation Service (ICC-ES):
   a. Evaluation Reports for Concrete and Masonry Anchors.
   b. AC01, Acceptance Criteria for Expansion Anchors in Masonry Elements.
   c. AC70, Acceptance Criteria for Fasteners Power-driven into Concrete, Steel and Masonry Elements.
   d. AC106, Acceptance Criteria for Predrilled Fasteners (Screw Anchors) in Masonry Elements.
   e. AC193, Acceptance Criteria for Mechanical Anchors in Concrete Elements.
   f. AC308, Acceptance Criteria for Post-Installed Adhesive Anchors in Concrete Elements. Evaluation Reports for Concrete and Masonry Anchors.
7. NSF International (NSF): 61, Drinking Water System Components - Health Effects.
8. Specialty Steel Industry of North America (SSINA):
   a. Specifications for Stainless Steel.
   b. Design Guidelines for the Selection and Use of Stainless Steel.
   c. Stainless Steel Fabrication.
   d. Stainless Steel Fasteners.

1.02 DEFINITIONS

A. Corrosive Area: Containment area or area exposed to delivery, storage, transfer, or use of chemicals.

B. Exterior Area: Location not protected from weather by a building or other enclosed structure to include buried roof structures.

C. Interior Dry Area: Location inside building or structure where floor is not subject to liquid spills or wash down, and where wall or roof slab is not common to a water-holding or earth-retaining structure.

D. Interior Wet Area: Location inside building or structure where floor is sloped to floor drains or gutters and is subject to liquid spills or wash down, or where wall, floor, or roof slab is common to a water-holding or earth-retaining structure.

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E. Submerged: Location at or below top of wall of open water-holding structure, such as a basin or channel, or wall, ceiling, or floor surface inside a covered water-holding structure, or exterior belowgrade wall or roof surface of water-holding structure, open or covered.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings: Specific instructions for concrete anchor installation, including drilled hole size and depth, preparation, placement, procedures, and instructions for safe handling of anchoring systems.

B. Informational Submittals:

1. Concrete and Masonry Anchors:
   a. Manufacturer's product description and installation instructions.
   b. Current ICC-ES or IAPMO-UES Report for each type of post-installed anchor to be used.
   c. Adhesive Anchor Installer Certification.
2. Passivation method for stainless steel members.
3. Hot-Dip Galvanizing: Certificate of compliance signed by galvanizer, with description of material processed and ASTM standard used for coating.

1.04 QUALITY ASSURANCE

A. Qualifications:

1. Installers of adhesive anchors horizontally or upwardly inclined to support sustained tension loads shall be certified by an applicable certification program. Certification shall include written and performance tests in accordance with the ACI/CRSI Adhesive Installer Certification Program or equivalent.
2. Galvanized Coating Applicator: Company specializing in hot-dip galvanizing after fabrication and following procedures of Quality Assurance Manual of the American Galvanizers Association.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Package stainless steel items in a manner to provide protection from carbon impregnation.

B. Protect hot-dip galvanized finishes from damage as a result of metal banding and rough handling.

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PART 2 PRODUCTS

2.01 GENERAL

A. Unless otherwise indicated, meet the following requirements:

Item	ASTM Reference
Stainless Steel:	
Threaded Rods	F593, AISI Type 316, Condition CW
Nuts*	F594, AISI Type 316, Condition CW
Carbon Steel:	
Threaded Rods	F1554, Grade 36 or F568M Class 5.8 [A193/A193M, Grade B7]
Flat and Beveled Washers (Hardened)	F436
Nuts*	A194/A194M, Grade 2H
Galvanized Steel:	
All	A153/A153M
*Nuts of other grades and styles having specified proof load stresses greater than specified grade and style are also suitable. Nuts must have specified proof load stresses equal to or greater than minimum tensile strength of specified threaded rod.	

B. Bolts, Washers, and Nuts: Use stainless steel, hot-dip galvanized steel, and zinc-plated steel material types as indicated in the Fastener Schedule at end of this section.

2.02 POST-INSTALLED CONCRETE ANCHORS

A. General:

1. AISI Type 316 stainless, hot-dip galvanized or zinc-plated steel, as shown in Fastener Schedule at end of this section.
2. Post-installed anchor systems used in concrete shall be approved by ICC Evaluation Services Report or equivalent for use in cracked concrete and for short-term and long-term loads including wind and earthquake.
3. Mechanical Anchors: Comply with the requirements of ICC-ES AC193 or ACI 355.2.
4. Adhesive Anchors: Comply with the requirements of ICC-ES AC308 or ACI 355.4.
5. Acceptable for use in potable water structures by EPA and local health agencies or NSF 61.

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B. Torque-Controlled Expansion Anchors (Wedge Anchors):

1. Manufacturers and Products:
   a. Hilti, Inc., Tulsa, OK; Kwik-Bolt –TZ (KB-TZ) Anchors (ESR-1917).
   b. Powers Fasteners, Brewster, NY; Power-Stud +SD1, +SD2, +SD4, or +SD6 Anchors (ESR-2502 and ESR-2818).
   c. Simpson Strong-Tie Co., Inc., Pleasanton, CA; Strong-Bolt 2 Anchors (ESR-1771 and ESR-3037).

C. Undercut Anchors:

1. Manufacturers and Products:
   a. USP Structural Connectors, Burnsville, MN; DUC Undercut Anchor (ESR-1970).
   b. Hilti, Inc., Tulsa, OK; HDA Undercut Anchor (ESR-1546).
   c. Simpson Strong-Tie Co., Inc., Pleasanton, CA; TORQ-CUT Self-Undercutting Anchor (ESR-2705).
   d. Powers Fasteners, Brewster, NY; Atomic+ Undercut Anchor (ESR-3067).

D. Self-Tapping Concrete Screw Anchors:

1. Manufacturers and Products:
   a. Powers Fasteners, Brewster, NY; Wedge-Bolt+ (ESR-2526).
   b. Powers Fasteners, Brewster, NY; Vertigo+ Rod Hanger Screw Anchor (ESR-2989).
   c. Powers Fasteners, Brewster, NY; Snake+ Flush Mount Screw Anchor (ESR-2272).
   d. Hilti, Inc., Tulsa, OK; HUS-EZ Screw Anchor (ESR-3027).
   e. Simpson Strong-Tie Co., Inc., Pleasanton, CA; Titen HD Screw Anchor (ESR-2713).

E. Adhesive Anchors:

1. Threaded Rod:
   a. Diameter as shown on Drawings.
   b. Length as required to provide minimum depth of embedment indicated and thread projection required.
   c. Clean and free of grease, oil, or other deleterious material.
2. Adhesive:
   a. Two-component, insensitive to moisture, designed to be used in adverse freeze/thaw environments.
   b. Cure Temperature, Pot Life, and Workability: Compatible for intended use and anticipated environmental conditions.

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3. Packaging and Storage:
    a. Disposable, self-contained system capable of dispensing both components in proper mixing ratio and fitting into a manually or pneumatically operated caulking gun.
    b. Store adhesive on pallets or shelving in a covered storage area.
    c. Package Markings: Include manufacturer's name, product name, batch number, product expiration date, ANSI hazard classification, and appropriate ANSI handling precautions.
    d. Dispose of When:
        1) Shelf life has expired.
        2) Stored other than in accordance with manufacturer's instructions.
4. Manufacturers and Products:
    a. Hilti, Inc., Tulsa, OK; HIT Doweling Anchor System, HIT RE 500 SD (ESR-2322), or HIT-HY 200 (ESR-3187).
    b. Simpson Strong-Tie Co., Inc., Pleasanton, CA; SET-XP Epoxy Adhesive Anchors (ESR-2508), or AT-XP Adhesive Anchors (IAPMO UES-263).
    c. Powers Fasteners, Brewster NY; Pure 110+ Epoxy adhesive anchor system (ESR-3298).

F. Adhesive Threaded Inserts:

1. Type 316 stainless steel, internally threaded inserts.
2. Manufacturer and Product: Hilti, Inc., Tulsa, OK; HIS-RN Insert with HIT-RE 500-SD or HIT-HY 200 adhesive.

2.03 POST-INSTALLED MASONRY ANCHORS

A. General: AISI Type 316 stainless, hot-dip galvanized, or zinc-plated steel, as shown in Fastener Schedule at end of section.

B. Current ICC Evaluation Report indicating acceptance for anchors at structural applications in masonry.

C. Manufacturers and Products:

1. Hilti, Inc., Tulsa, OK; Kwik-Bolt-3 (KB-3) (ESR-1385), for grout-filled masonry, HIT-HY 70 (ESR-2682) for grout filled CMU, hollow CMU, or unreinforced masonry.
2. Simpson Strong-Tie Co., Inc., Pleasanton, CA; Strong-Bolt 2 (IAPMO ER 240) for grout filled CMU, Titen-HD (ESR-1056) for grout filled or hollow CMU, AT-XP (IAPMO ER-281) for grout filled CMU.
3. Powers Fasteners, Brewster NY; Power-Stud+ SD1 (ESR-2966) for grout-filled masonry, Wedgebolt+ (ESR-1678) for grout-filled masonry.

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PART 3 EXECUTION

3.01 CONCRETE AND MASONRY ANCHORS

A. Begin installation only after concrete or masonry to receive anchors has attained design strength.

B. Locate existing reinforcing with Ground Penetrating Radar or other method approved by Engineer prior to drilling. Coordinate with Engineer to adjust anchor locations where installation would result in hitting reinforcing.

C. Install in accordance with written manufacturer's instructions.

D. Provide minimum embedment, edge distance, and spacing as indicated on Drawings.

E. Use only drill type and bit type and diameter recommended by anchor manufacturer.

F. Clean hole of debris and dust per manufacturer's requirements.

G. When unidentified embedded steel, rebar, or other obstruction is encountered in drill path, slant drill to clear obstruction. If drill must be slanted more than indicated in manufacturer's installation instructions to clear obstruction, notify Engineer for direction on how to proceed.

H. Adhesive Anchors:

1. Unless otherwise approved by Engineer and adhesive manufacturer:
    a. Do not install adhesive anchors when temperature of concrete or masonry is below 40 degrees F or above 100 degrees F.
    b. Do not install prior to concrete attaining an age of 21 days.
    c. Remove any standing water from hole with oil-free compressed air. Inside surface of hole shall be dry.
    d. Do not disturb anchor during recommended curing time.
    e. Do not exceed maximum torque as specified in manufacturer's instructions.
2. For hollow-unit masonry, install screen tube in accordance with manufacturer's instructions.

I. Prestressed Concrete: Do not use drilled-in anchors in prestressed or post-tensioned concrete members without Engineer's prior approval unless specifically shown on Drawings.

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3.02 FIELD QUALITY ASSURANCE AND QUALITY CONTROL

A. Owner-Furnished Quality Assurance, in accordance with IBC Chapter 17 requirements, is provided in the Statement of Special Inspections Plan on Drawings. Contractor responsibilities and related information are included in Section 01 45 33, Special Inspection, Observation, and Testing.

B. Contractor-Furnished Quality Control: Inspection and testing as required in Section 01 45 16.13, Contractor Quality Control.

3.03 MANUFACTURER'S SERVICES

A. Adhesive and Mechanical Anchors: Conduct Site training of installation personnel for proper installation, handling, and storage of adhesive anchor system. Notify Engineer of time and place for sessions.

3.04 FASTENER SCHEDULE

A. Unless indicated otherwise on Drawings, provide fasteners as follows:

Service Use and Location	Product	Remarks
1. Post Installed Anchors for Metal Components to Cast-in-Place Concrete (such as, Ladders, Handrail Posts, Electrical Panels, Platforms, and Equipment)		
Interior Dry Areas	Anchor material type to match material being anchored (for example, stainless steel anchors to anchor stainless steel equipment, zinc plated anchors to anchor painted equipment, galvanized anchors to anchor galvanized equipment).	Verify product acceptability and manufacturer's requirements if anchor installation will occur in an overhead application
Submerged, Exterior, Interior Wet, and Corrosive Areas	Stainless steel anchors	Verify product acceptability and manufacturer's requirements if anchor installation will occur in an overhead application

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Service Use and Location	Product	Remarks
2. Anchors in Grout-Filled Concrete Masonry Units		
Interior Dry Areas	Anchor material type to match material being anchored (for example, stainless steel anchors to anchor stainless steel equipment, zinc plated anchors to anchor painted equipment, galvanized anchors to anchor galvanized equipment).	
Submerged, Exterior, Interior Wet, and Corrosive Areas	Stainless steel anchors	
3. Anchors in Hollow Concrete Masonry Units		
Interior Dry Areas	Anchor material type to match material being anchored (for example, stainless steel anchors to anchor stainless steel equipment, zinc plated anchors to anchor painted equipment, galvanized anchors to anchor galvanized equipment).	Adhesive anchors shall be installed with screen tubes.
Exterior, Interior Wet, and Corrosive Areas	Stainless steel anchors	Adhesive anchors shall be installed with screen tubes.
4. All Others		
All service uses and locations	Stainless steel fasteners	

B. Antiseizing Lubricant: Use on all stainless steel threads.

C. Do not use adhesive anchors to support fire-resistive construction or where ambient temperature will exceed 120 degrees F.

END OF SECTION

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SECTION 05 05 23
WELDING

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards that may be referenced in this section:

1. American Society of Mechanical Engineers (ASME):
   a. BPVC SEC V, Nondestructive Examination.
   b. BPVC SEC IX, Welding and Brazing Qualifications.
2. American Society of Nondestructive Testing (ASNT): SNT-TC-1A, Personnel Qualification and Certification in Nondestructive Testing.
3. ASTM International (ASTM): A370, Standard Test Methods and Definitions for Mechanical Testing of Steel Products.
4. American Welding Society (AWS):
   a. A2.4, Standard Symbols for Welding, Brazing, and Nondestructive Examination.
   b. A3.0, Standard Welding Terms and Definitions.
   c. D1.1/D1.1M, Structural Welding Code - Steel.
   d. D1.8/D1.8M, Structural Welding Code - Seismic Supplement.
   e. D1.2/D1.2M, Structural Welding Code - Aluminum.
   f. D1.3/1.3M, Structural Welding Code - Sheet Steel.
   g. D1.6/D1.6M, Structural Welding Code - Stainless Steel.
   h. QC1, Standard for AWS Certification of Welding Inspectors.

1.02 DEFINITIONS

A. CJP: Complete Joint Penetration.

B. CWI: Certified Welding Inspector.

1. Contractor's Welding Inspection: Contractor's CWI acts for, and on behalf of, the Contractor on all inspection and quality matters within the scope of the Contract Documents. Contractor is required to provide a welding inspector to oversee welding operations and be responsible for visual inspection and necessary correction of all deficiencies in materials and workmanship required to meet referenced welding codes. This type of Quality Control Inspection is not classified as Special Inspection.
2. Verification Inspector: CWI who acts on behalf of the Owner. This type of independent inspection and testing is the prerogative of the Owner, who may perform this function, or waive independent verification inspection if it is not required by the building official and building code.

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C. MT: Magnetic Particle Testing.

D. NDE: Nondestructive Examination.

E. NDT: Nondestructive Testing.

F. PJP: Partial Joint Penetration.

G. PQR: Procedure Qualification Record.

H. PT: Liquid Penetrant Testing.

I. Special Inspection: Non-destructive examination, other than Contractor's CWI Visual Inspection. Special inspection includes MT, PT, UT, RT, and Verification Inspection. Special Inspection personnel report to, and are retained by Engineer on behalf of the Owner. See additional requirements in Section 01 45 33, Special Inspection, Observation, and Testing.

J. RT: Radiographic Testing.

K. UT: Ultrasonic Testing.

L. VT: Visual Testing.

M. WPQ: Welder/Welding Operator Performance Qualification.

N. WPS: Welding Procedure Specification.

1.03 SUBMITTALS

A. Shop Drawings:

1. Shop and field WPSs and PQRs.
2. NDT procedure specifications prepared in accordance with ASME BPVC SEC V.
3. Welding Data (Shop and Field): Submit welding data together with Shop Drawings as a complete package.
    a. Show on Shop Drawings, or on a weld map, complete information regarding base metal specification designation, location, type, size, and extent of welds with reference called out for WPS and NDE numbers in tails of combined welding and NDE symbols as indicated in AWS A2.4.
    b. Clearly distinguish between shop and field welds.
    c. Indicate, by welding symbols or sketches, details of welded joints and preparation of base metal. Provide complete joint welding details showing bevels, groove angles, and root openings for welds.
    d. Welding and NDE Symbols: In accordance with AWS A2.4.

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e. Welding Terms and Definitions: In accordance with AWS A3.0.
f. For pipe fittings, provide a joint weld beveling diagram. Refer to AWS D1.1/D1.1M, Annex P Local Dihedral Angle that can be used to calculate bevels for weld joint details of intersecting pipes.

B. Informational Submittals:

1. WPQs.
2. CWI credentials.
3. Testing agency personnel credentials.
4. CWI visual inspection (VT) reports.
5. Welding Documentation: Submit on forms in referenced welding codes.

1.04 QUALIFICATIONS

A. WPSs: In accordance with AWS D1.1/D1.1M (Annex N Forms) for shop or field welding; or ASME BPVC SEC IX (Forms QW-482 and QW-483) for shop welding only.

B. WPQs: In accordance with AWS D1.1/D1.1M (Annex N Forms); or ASME BPVC SEC IX (Form QW-484).

C. CWI: Certified in accordance with AWS QC1, and having prior experience with specified welding codes. Alternate welding inspector qualifications require approval by Engineer.

D. Testing Agency: Personnel performing tests shall be NDT Level II certified in accordance with ASNT SNT-TC-1A.

1.05 SEQUENCING AND SCHEDULING

A. Unless otherwise specified, Submittals required in this section shall be submitted and approved prior to commencement of welding operations.

PART 2 PRODUCTS

2.01 SOURCE QUALITY CONTROL

A. Fabricator's CWI shall be present whenever shop welding is performed. CWI shall perform inspection, at suitable intervals, prior to assembly, during assembly, during welding, and after welding. CWI shall perform inspections as required in AWS D1.1/D1.1M or referenced welding code and as follows:

1. Verifying conformance of specified job material and proper storage.
2. Monitoring conformance with approved WPS.
3. Monitoring conformance of WPQ.
4. Inspecting weld joint fit-up and performing in-process inspection.

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5. Providing 100 percent visual inspection of welds.
6. Supervising nondestructive testing personnel and evaluating test results.
7. Maintaining records and preparing report confirming that the results of inspection and testing comply with the Work.

PART 3 EXECUTION

3.01 GENERAL

A. Welding and Fabrication by Welding: Conform to governing welding codes referenced in attached Welding and Nondestructive Testing Table.

3.02 NONDESTRUCTIVE WELD TESTING REQUIREMENTS

A. Weld Inspection Criteria:

1. Selection of welds to be tested, unless 100 percent NDT is specified herein, shall be as agreed upon between Engineer and Contractor.
2. Unless otherwise specified, perform NDT of welds at a frequency as shown below and in the attached Table in accordance with referenced welding codes as follows. Perform UT on CJP groove welds that cannot be readily radiographed. In case there is a conflict, higher frequency level of NDT shall apply.
   a. CJP Groove, Butt Welds: 10 percent random RT.
   b. All Other CJP Groove Welds: 10 percent random UT.
   c. Fillet Welds and PJP Groove Welds: 10 percent random PT or MT.
   d. All Welds: 100 percent VT.
3. Weld Acceptance:
   a. VT:
      1) Structural Pipe and Tubing: AWS D1.1/D1.1M, Paragraph 6.9, Visual Inspection, Tubular Connections.
      2) All Other Structural Steel: AWS D1.1/D1.1M, Paragraph 6.9, Visual Inspection, Statically Loaded Nontubular Connections.
      3) Stud Connections: AWS D1.1/D1.1M, Paragraph 7.8.1.
   b. UT: Perform on CJP groove welds in accordance with AWS D1.1/D1.1M, Paragraph 6.13.3, Class R Indications.
   c. RT: Perform on CJP butt joint welds in accordance with AWS D1.1/D1.1M, Paragraph 6.12.1.
   d. PT or MT:
      1) Perform on fillet and PJP groove welds in accordance with AWS D1.1/D1.1M, Paragraph 6.10.
      2) Acceptance shall be in accordance with VT standards specified above.

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3.03 FIELD QUALITY CONTROL

A. CWI shall be present whenever field welding is performed. CWI shall perform inspection, at suitable intervals, prior to assembly, during assembly, during welding, and after welding. CWI shall perform inspections as required in AWS D1.1/D1.1M or referenced welding code and as follows:

1. Verify conformance of specified job material and proper storage.
2. Monitor conformance with approved WPS.
3. Monitor conformance of WPQ.
4. Inspect weld joint fit-up and perform in-process inspection.
5. Provide 100 percent visual inspection of all welds.
6. Supervise nondestructive testing personnel and evaluating test results.
7. Maintain records and prepare report confirming results of inspection and testing comply with the Work.

3.04 WELD DEFECT REPAIR

A. Repair and retest rejectable weld defects until sound weld metal has been deposited in accordance with appropriate welding codes.

3.05 SUPPLEMENTS

A. The supplement listed below, following “End of Section,” is a part of this specification.

1. Welding and Nondestructive Testing Table.

END OF SECTION

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Welding and Nondestructive Testing						
Specification Section	**Governing Welding Codes or Standards**	**Submit WPS**	**Submit WPQ**	**Onsite CWI Req'd**	**Submit Written NDT Procedure Specifications**	**NDT Requirements**
03 40 00 Precast Concrete	AWS D1.1/D1.1M, Structural Welding Code - Steel and AWS D1.4/D1.4M, Structural Welding Code - Reinforcing Steel	No	Yes	Yes	Yes	100% VT; also see Section 03 40 00
05 12 00 Structural Steel Framing	AWS D1.1/D1.1M, Structural Welding Code - Steel	Yes	Yes	Yes	Yes	10% UT or RT of all groove-and-butt joint welds; 10% MT of all fillet welds; also see Section 05 12 00
05 21 19 Open Web Steel Joists Framing	AWS D1.1/D1.1M, Structural Welding Code - Steel	Yes	Yes	Yes	Yes	100% VT; also see Section 05 21 19
05 31 00 Steel Decking	AWS D1.1/D1.1M, Structural Welding Code - Steel or AWS D1.3/D1.3M, Structural Welding Code - Sheet Steel	Yes	Yes	Yes	Yes	100% VT; also see Section 05 31 00
05 41 00 Structural Metal Stud Framing	AWS D1.1/D1.1M, Structural Welding Code - Steel or AWS D1.3/1.3M, Structural Welding Code - Sheet Steel	Yes	Yes	Yes	Yes	100% VT; also see Section 05 41 00
05 50 00 Metal Fabrications	AWS D1.1/D1.1M, Structural Welding Code– Steel or AWS D1.2/D1.2M, Structural Welding Code - Aluminum or AWS D1.6/D1.6M, Structural Welding Code - Stainless Steel	Yes	Yes	Yes	Yes	100% VT; also see Section 05 50 00
05 52 16, Aluminum Railings	AWS D1.1/D1.1M, Structural Welding Code - Steel or AWS D1.2/D1.2M, Structural Welding Code - Aluminum	No	No	No	No	100% VT; also see Section 05 52 16, Aluminum Railings
05 53 00 Metal Gratings	AWS D1.1/D1.1M, Structural Welding Code - Steel or AWS D1.2/D1.2M, Structural Welding Code - Aluminum	No	No	No	No	100% VT; also see Section 05 53 00
33 16 13.13 Welded Steel Tank	ASME BPV Code, Section IX or AWS D1.1/D1.1M, Structural Welding Code - Steel	Yes	Yes	Yes	Yes	100% VT and AWWA D100; also see Section 33 16 13.13

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SECTION 05 50 00
METAL FABRICATIONS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. The Aluminum Association, Inc. (AA): The Aluminum Design Manual.
2. American Galvanizers Association (AGA):
   a. Inspection of Hot-Dip Galvanized Steel Products.
   b. Quality Assurance Manual.
3. American Iron and Steel Institute (AISI): Stainless Steel Types.
4. American Ladder Institute (ALI): A14.3, Ladders - Fixed - Safety Requirements.
5. American National Standards Institute (ANSI).
6. American Society of Safety Engineers (ASSE): A10.11, Safety Requirements for Personnel and Debris Nets.
7. American Welding Society (AWS):
   a. D1.1/D1.1M, Structural Welding Code - Steel.
   b. D1.2/D1.2M, Structural Welding Code - Aluminum.
   c. D1.6/D1.6M, Structural Welding Code - Stainless Steel.
8. ASTM International (ASTM):
   a. A36/A36M, Standard Specification for Carbon Structural Steel.
   b. A48/A48M, Specification for Gray Iron Castings.
   c. A53/A53M, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
   d. A108, Standard Specification for Steel Bar, Carbon and Alloy, Cold-Finished.
   e. A123/A123M, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   f. A143/A143M, Standard for Safeguarding Against Embrittlement of Hot-Dip Galvanized Structural Steel Products and Procedure for Detecting Embrittlement.
   g. A153/A153M, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
   h. A193/A193M, Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
   i. A194/A194M, Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.

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j. A240/A240M, Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
k. A276, Standard Specification for Stainless Steel Bars and Shapes.
l. A283/A283M, Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates.
m. A307, Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength.
n. A325, Standard Specification for Structural Bolts, Steel, Heat Treated 120/105 ksi Minimum Tensile Strength.
o. A380, Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.
p. A384/A384M, Standard Practice for Safeguarding Against Warpage and Distortion During Hot-Dip Galvanizing of Steel Assemblies.
q. A385/A385M, Standard Practice for Providing High-Quality Zinc Coatings (Hot-Dip).
r. A489, Standard Specification for Carbon Steel Lifting Eyes.
s. A500/A500M, Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes.
t. A501, Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing.
u. A563, Standard Specification for Carbon and Alloy Steel Nuts.
v. A653/A653M, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
w. A780/A780, Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings.
x. A786/A786M, Standard Specification for Hot-Rolled Carbon, Low-Alloy, High-Strength Low-Alloy, and Alloy Steel Floor Plates.
y. A793, Standard Specification for Rolled Floor Plate, Stainless Steel.
z. A967, Standard Specification for Chemical Passivation Treatments for Stainless Steel Parts.
aa. A992/A992M, Standard Specification for Structural Steel Shapes.
bb. A1085, Standard Specification for Cold-Formed Welded Carbon Steel Hollow Structural Sections (HSS).
cc. B209, Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
dd. B308/B308M, Standard Specification for Aluminum-Alloy 6061-T6 Standard Structural Profiles.
ee. B429/B429M, Standard Specification for Aluminum-Alloy Extruded Structural Pipe and Tube.

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ff. B632/B632M, Standard Specification for Aluminum-Alloy Rolled Tread Plate.
gg. C881/C881M, Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete.
hh. D1056, Standard Specification for Flexible Cellular Materials - Sponge or Expanded Rubber.
ii. F436, Standard Specification for Hardened Steel Washers.
jj. F468, Standard Specification for Nonferrous Bolts, Hex Cap Screws, and Studs for General Use.
kk. F593, Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
ll. F594, Standard Specification for Stainless Steel Nuts.
mm. F844, Standard Specification for Washers, Steel, Plain (Flat), Unhardened for General Use.
nn. F1554, Standard Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength.

9. NSF International (NSF): 61, Drinking Water System Components—Health Effects.
10. Occupational Safety and Health Administration (OSHA):
    a. 29 CFR 1910.27, Fixed Ladders.
    b. 29 CFR 1926.105, Safety Nets.
    c. 29 CFR 1926.502, Fall Protection Systems Criteria and Practices.
11. Specialty Steel Industry of North America (SSINA):
    a. Specifications for Stainless Steel.
    b. Design Guidelines for the Selection and Use of Stainless Steel.
    c. Stainless Steel Fabrication.
    d. Stainless Steel Fasteners.

1.02 DEFINITIONS

A. Anchor Bolt: Cast-in-place anchor; concrete or masonry.

B. Corrosive Area: Containment area or area exposed to delivery, storage, transfer, or use of chemicals.

C. Exterior Area: Location not protected from weather by building or other enclosed structure.

D. Interior Dry Area: Location inside building or structure where floor is not subject to liquid spills or washdown, nor where wall or roof slab is common to a water-holding or earth-retaining structure.

E. Interior Wet Area: Location inside building or structure where floor is sloped to floor drains or gutters and is subject to liquid spills or washdown, or where wall, floor, or roof slab is common to a water-holding or earth-retaining structure.

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F. Submerged: Location at or below top of wall of open water-holding structure, such as basin or channel, or wall, ceiling or floor surface inside a covered water-holding structure, or exterior belowgrade wall or roof surface of water-holding structure, open or covered.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings: Metal fabrications, including welding and fastener information.

B. Informational Submittals:

1. U-Channel Concrete Inserts:
   a. Manufacturer's product description.
   b. Allowable load tables.
2. Pre-engineered Ladders: Letter of certification that ladder meets OSHA 29 CFR 1910.27 requirements.
3. Passivation method for stainless steel members.
4. Galvanized coating applicator qualifications.
5. Hot-Dip Galvanizing: Certificate of compliance signed by galvanizer, with description of material processed and ASTM standard used for coating.

1.04 QUALITY ASSURANCE

A. Qualifications:

1. Galvanized Coating Applicator: Company specializing in hot-dip galvanizing after fabrication and following procedures of Quality Assurance Manual of the American Galvanizers Association.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Insofar as practical, factory assemble specified items. Package assemblies, which have to be shipped unassembled to protect materials from damage and tag to facilitate identification and field assembly.

B. Package stainless steel items to provide protection from carbon impregnation.

C. Protect painted coatings and hot-dip galvanized finishes from damage as a result of metal banding and rough handling. Use padded slings and straps.

D. Store fabricated items in dry area, not in direct contact with ground.

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1.06 SPECIAL GUARANTEE

A. Manufacturer's extended guarantee or warranty, with Owner named as beneficiary, in writing, as special guarantee. Special guarantee shall provide for correction, or at option of Owner, removal and replacement of sidewalk doors and floor hatches found defective during a period of 5 years after date of Substantial Completion. Duties and obligations for correction or removal and replacement of defective Work as specified in General Conditions.

1.07 EXTRA MATERIALS

A. Furnish, tag, and box for shipment and storage the following extra materials:

Item	Quantity
Neoprene Gasket	Two for each location requiring neoprene gaskets.

B. Delivery: In accordance with Section 01 61 00, Common Product Requirements.

PART 2 PRODUCTS

2.01 GENERAL

A. For hot-dip galvanized steel that is exposed to view and does not receive paint, limit the combined phosphorus and silicon content to 0.04 percent. For steels that require a minimum of 0.15 percent silicon (such as plates over 1.5 inches thick for ASTM A36/A36M steel), limit maximum silicon content to 0.21 percent and phosphorous content to 0.03 percent.

B. Unless otherwise indicated, meet the following requirements:

Item	ASTM Reference
Steel Wide Flange Shapes	A992/992M
Other Steel Shapes and Plates	A36/A36M or A572/A572M, Grade 50 or A992/A992M for other steel shapes
Steel Pipe	A500, Grade B
Hollow Structural Sections (HSS)	A500/A500M, Grade C
Aluminum:	
Aluminum Plates	B209, Alloy y6061-T6
Aluminum Structural Shapes	B308/B308M, Alloy 6061-T6

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Item	ASTM Reference
Stainless Steel:	
Bars and Angles	A276, AISI Type 316 (316L for welded connections)
Shapes	A276, AISI Type 304 (304L for welded connections)
Steel Plate, Sheet, and Strip	A240/A240M, AISI Type 316 (316L for welded connections)
Bolts, Threaded Rods, Anchor Bolts, and Anchor Studs	F593, AISI Type 316, Group 2, Condition SH
Nuts	F594, AISI Type 316, Condition CW
Steel Bolts and Nuts:	
Carbon Steel	A307 bolts, with A563 nuts
High-Strength	A325, Type 1 bolts, with A563 nuts
Anchor Bolts and Rods	F1554, Grade 55, with weldability supplement S1.
Eyebolts	A489
Threaded Rods	A36/A36M
Flat Washers (Unhardened)	F844
Flat and Beveled Washers (Hardened)	F436
Thrust Ties for Steel Pipe:	
Threaded Rods	A193/A193M, Grade B7
Nuts	A194/A194M, Grade 2H
Plate	A283/A283M, Grade D
Welded Anchor Studs	A108, Grades C-1010 through C-1020
Aluminum Bolts and Nuts	F468, Alloy 2024-T4
Cast Iron	A48/A48M, Class 35

C. Bolts, Washers, and Nuts: Use stainless steel, hot-dip galvanized steel, zinc-plated steel, and aluminum material types as indicated in Fastener Schedule at end of this section.

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2.02 ANCHOR BOLTS AND ANCHOR BOLT SLEEVES

A. Cast-In-Place Anchor Bolts:

1. Headed type, unless otherwise shown on Drawings.
2. Material type and protective coating as shown in Fastener Schedule at end of this section.

B. Anchor Bolt Sleeves:

1. Plastic:
   a. Single unit construction with corrugated sleeve.
   b. Top of sleeve shall be self-threading to provide adjustment of threaded anchor bolt projection.
   c. Material: High-density polyethylene.
2. Fabricated Steel: ASTM A36/A36M.

2.03 POST-INSTALLED CONCRETE AND MASONRY ANCHORS

A. See Section 05 05 19, Post-Installed Anchors.

2.04 STUD SHEAR CONNECTORS

A. Headed anchor studs (HAS), or threaded anchor studs (TAS),or stud shear connectors, as indicated on Drawings.

1. Carbon Steel: ASTM A108, Standard Quality Grades 1010 through 1020, inclusive either semikilled or killed aluminum or silicon dioxidation, unless indicated otherwise.
2. Stainless Steel: ASTM F593, AISI Type 316, Condition CW, where indicated.

B. Manufacturers:

1. Nelson Stud Welding, FabriSteel Co., Elyria, OH.
2. Stud Welding Associates, Inc., Elyria, OH.

2.05 PIPE SLEEVES

A. As specified in Section 40 27 00, Process Piping--General.

2.06 STEEL LINTELS AND SHELF ANGLES

A. ASTM A36/A36M, hot-dip galvanize after fabrication in accordance with ASTM A123/A123M.

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2.07 EMBEDDED STEEL SUPPORT FRAMES FOR FLOOR PLATE AND GRATING

A. Steel angle support frames to be embedded in concrete shall be stainless steel, ASTM A276, AISI Type 316, unless indicated otherwise.

B. Welded anchors for stainless steel support frames shall also be stainless steel.

2.08 U-CHANNEL CONCRETE INSERTS

A. Rolled ASTM A240/A240M, AISI Type 316 stainless steel, 0.105-inch-thick, 1-5/8 inches wide by 1-3/8 inches deep, with stainless steel anchors at 10-inch maximum spacing, styrofoam fillers, and end caps.

B. Nut and Bolt Hardware: Type 316 stainless steel, 5/8-inch minimum diameter, unless indicated otherwise. Manufacturer's standard to match insert.

C. Manufacturers and Products:

1. Power-Strut, Wayne, MI; PS 349 Series.
2. B-Line Systems, Inc., Highland, IL; B32 Series.
3. Halfen Anchoring Systems, Converse, TX; Channel Type 4141HTA.

2.09 ABRASIVE NOSING FOR STAIRS

A. Unless otherwise shown on Drawings, furnish flush type abrasive nosings on stairs.

B. Nosing Components:

1. Homogeneous epoxy abrasive, with minimum 50 percent aluminum oxide content, formed and cured upon an extruded aluminum base.
2. Epoxy abrasive shall extend over and form curved front edge of nosing.
3. Base of Nosing: Extruded aluminum alloy, 6063-T5, heat-treated.

C. Anchoring System: Double-set anchors consisting of two rows of integrally extruded anchors.

D. Size: 3 inches wide by 1/4 inch to 3/8 inch thick by length as shown.

E. Color: Selected by Engineer from manufacturer's standard color range.

F. Manufacturers and Products:

1. Wooster Products, Inc., Wooster, OH; Spectra Type WP3J and Spectra Type WP3C.
2. American Safety Tread Co., Inc., Helena, AL; Type BF-311D and Type FA-311D.

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2.10 FLOOR PLATE

A. Material:

1. Galvanized Steel: Carbon steel, ASTM A786/A786M, commercial grade, hot-dip galvanized after fabrication in accordance with ASTM A123/A123M.
2. Stainless Steel: ASTM A793, AISI Type 304.
3. Aluminum: ASTM B632/B632M, Alloy 6061-T6.

B. Minimum Thickness:

1. Steel: 1/4 inch, unless shown otherwise on Drawings.
2. Aluminum: 3/8 inch, unless shown otherwise on Drawings.

C. Surface: Raised-lug pattern or diamond tread, unless shown otherwise on Drawings.

D. Slip-Resistant Surface:

1. Provide where indicated on Drawings.
2. Manufacturers and Products:
   a. IKG/Borden, Clark, NJ; MEBAC 2.
   b. W.S. Molnar Co., Detroit, MI; SLIPNOT Grade 2–Medium.

2.11 EXTRUDED FLOOR PLATE

A. Extruded Deck Plate:

1. Minimum Section Height: As shown on Drawings.
2. Minimum Section Width: 12 inches.
3. Accessories: Anchor clamp fixtures.
4. Manufacturer and Product: Alcoa Building Products, Inc., Sidney, OH; Standard Diamondback.

B. Extruded Tread Plate:

1. Minimum Section Height: 0.360 inch, plus serrations.
2. Section Width: 12 inches.
3. Accessories: Edgebands, tongue-and-groove attachment.
4. Manufacturer and Product: Alcoa Building Products, Inc., Sidney, OH; Standard Diamondback.

2.12 SIDEWALK DOORS

A. Load Capacity: 300 psf with maximum deflection of 1/150th of span. Provide H-20 wheel loading capacity where indicated on Drawings.

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B. Component Fabrication:

1. Access Door Leaf(s): 1/4-inch aluminum diamond pattern plate. Provide stainless steel safety chain and attachments for end of double-leaf door assembly when open.
2. Channel Frame: 1/4-inch-thick extruded aluminum trough frame with continuous anchor flange around perimeter. Weld 1-1/2-inch diameter drain coupling, and drain pipe, to frame trough at front right corner, unless indicated otherwise on Drawings.
3. Safety Grate: Aluminum grating with 300 psf live load capacity, 5-inch by 5-inch grate openings, permanent hinging system that locks grate in 90-degree position, and opening arm with vinyl grip handle and locking device.

C. Door Hardware:

1. Hinges: Heavy-duty brass or stainless steel with stainless steel pins through-bolted to cover plate with tamper-proof stainless steel bolts flush with top of cover and to outside leg of channel frame with stainless steel bolts and locknuts.
2. Lifting Mechanism: Stainless steel compression lift springs enclosed in telescoping vertical housing or stainless steel torsion lift springs.
3. Hold-Open Arm:
   a. Locks automatically in open position.
   b. Disengages with slight pull on vinyl grip with one hand.
   c. Door can be easily closed with one hand by pulling forward and down on vinyl grip.
4. Snap Lock:
   a. Stainless steel snap lock mounted on bottom of door leaf with removable topside key wrench and inside fixed lever handle.
   b. Threaded plug for flush outside surface with key wrench removed.

D. Aluminum: Mill finished with protective coating applied to surfaces to be in contact with concrete, as specified in Section 09 90 00, Painting and Coating.

E. Manufacturers and Products:

1. Bilco Co., New Haven, CT; J Series.
2. Nystrom Products Co., Minneapolis, MN; FG Series.
3. U.S.F. Fabrication, Hialeah, FL; T Series.
4. ITT Flygt Corporation, Trumbull, CT; FDRN Series.
5. Thompson Fabricating Co., Birmingham, AL; TE Series.
6. Halliday Products, Orlando, FL; WS Series.

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2.13 FLOOR HATCHES

A. Load Capacity: 300 psf with maximum deflection of 1/150th of span.

B. Component Fabrication:

1. Access Door Leaf(s): 1/4-inch-thick aluminum diamond pattern plate. Provide stainless steel safety chain and attachments for end of double-leaf door assembly when open.
2. Angle Frame: 1/4-inch thick extruded aluminum angle frame with concrete anchors and integral neoprene gasket strip.

C. Door Hardware:

1. Hinges: Heavy-duty brass or stainless steel with stainless steel pins, through-bolted to cover plate with tamper-proof stainless steel bolts flush with top of cover and to outside leg of channel frame with stainless steel bolts and locknuts.
2. Lifting Mechanism: Stainless steel compression lift springs enclosed in telescoping vertical housing or stainless steel torsion lift springs.
3. Hold-Open Arm:
   a. Locks automatically in open position.
   b. Disengages with slight pull on vinyl grip with one hand.
   c. Door can be easily closed with one hand by pulling forward and down on vinyl grip.
4. Snap Lock:
   a. Stainless steel snap lock mounted on bottom of door leaf with removable topside key wrench and inside fixed lever handle.
   b. Threaded plug for flush outside surface with key wrench removed.

D. Aluminum: Mill finished with protective coating applied to surfaces to be in contact with concrete, as specified in Section 09 90 00, Painting and Coating.

E. Manufacturers and Products:

1. Bilco Co., New Haven, CT; K Series.
2. Nystrom Products Co., Minneapolis, MN; FH Series.
3. U.S.F. Fabrication, Hialeah, FL; A Series.
4. ITT Flygt Corporation, Trumbull, CT; FLE Series.
5. Thompson Fabricating Co., Birmingham, AL; TI Series.
6. Halliday Products, Orlando, FL; SS Series.

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2.14 HATCH SAFETY NET

A. General:

1. Conforms to ASSE A10.11 and OSHA CFR Part 1926.105.
2. Size to fit hatch opening where indicated.

B. Components and Accessories:

1. Rails and Slide Rings: Aluminum 6061-T6 extruded rails and aluminum-alloy 713.0 slide rings.
2. Corner Hooks and Eyebolts: AISI Type 316 stainless steel.
3. Netting: Polyester, 5-inch by 5-inch net openings; 5,000 pounds minimum breaking strength.
4. Bolts, Nuts, and Concrete Anchors: AISI Type 316 stainless steel.

C. Manufacturer and Product: Safe Approach Inc., Auburn, ME; Hatch Net 121.

2.15 HINGED MANHOLE COVERS

A. Slab type rectangular manhole frame and cover with flush, waterproof lift handles, and stainless steel butt hinges.

B. ASTM A48/A48M, Class 35, cast iron, unpainted.

C. Furnish as shown in table:

Hinged Manhole Covers

Mark	Duty	Size (inches)	Weight (pounds)
HMC-1	Light	24 x 36	275
HMC-2	Light	30 x 30	290
HMC-3	Light	30 x 36	335
HMC-4	Light	30 x 48	450
HMC-5	Heavy	30 x 36	525
HMC-6	Heavy	36 x 36	700

D. Manufacturers:

1. Neenah Foundry Co., Neenah, WI.
2. Flockhart Foundry Co., Newark, NJ.

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2.16 LADDERS

A. Fabricate ladders with rails, rungs, landings, and cages to meet applicable requirements of OSHA, CFR Part 1910.27, and ALI A14.3.

1. Design ladder for concentrated load of 300 pounds imposed by user concentrated at points that will cause maximum stress in structural member being considered.
2. Include weight of ladder and attached appurtenances together with live load in design of rails and fastenings.
3. Self-closing gates at landings.

B. Flat Bar Ladder:

1. Punch rails, pass rungs through rails, and weld on outside.
2. Weld brackets to ladder for fastening ladder to wall.
3. ASTM A276, AISI Type 304L stainless steel.

C. Aluminum Pre-engineered Pipe Ladder:

1. Rungs:
   a. Aluminum extrusions of Alloy 6063-T6.
   b. Nonslip grip surface, 1-inch wide flat top, and semicircular bottom with mill finish.
2. Side Rails: ASTM B429/B429M, Alloy 6063-T6, 1-1/2 inches, Schedule 40 pipe with anodized finish, AA M32-C22-A41.
3. Ladder Attachments and Cage Assembly Fasteners: Stainless steel.
4. Welded, pop riveted, or glued construction is not acceptable.
5. Fabricate to longest length as practical but not to exceed 24 feet.
6. Furnish support attachments to side rails at 6 feet maximum spacing.
7. Manufacturer: Thompson Fabricating Co. Inc., Tarrant, AL.

D. Ladder Safety Post:

1. Telescoping tubular, spring balanced and automatically locking in raised position, with release lever for unlocking.
2. Post: Stainless steel, AISI Type 304. or Aluminum.
3. Hardware: Stainless steel, AISI Type 316.
4. Furnish dissimilar metal protective coatings at connections.
5. Manufacturer and Product: Bilco Co., New Haven, CT; “Ladder Up” to fit ladder rungs.

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2.17 SAFETY CLIMB DEVICE

A. General:

1. Conforms to ALI A14.3 and OSHA CFR Part 1910.27.
2. Belt and harness shall withstand minimum drop test of 250 pounds in 6-foot free fall.
3. Fall Prevention System Material: Stainless steel, AISI Type 316.

B. Components and Accessories:

1. Main Components: Sleeve or trolley, safety harness, and carrier or climbing rail.
2. Ladder rung clamps with stainless steel, AISI Type 316, mounting brackets and hardware.
3. Removable extension kit with tiedown rod or trolley gate, mandrel, and carrier rail for ladders under manholes and hatches.

C. Manufacturers and Products:

1. Miller by Honeywell, Franklin, PA; Miller Saf-T-Climb.
2. TS Products, Cambridge, Ontario, Canada; TS Safety Rail System.

2.18 FALL ARREST ANCHORS

A. General:

1. Conforms to OSHA CFR Part 1926.502.
2. Minimum Breaking Strength: 5,000 pounds.
3. Material: Stainless steel, AISI Type 304.

B. Components and Accessories:

1. Forged combination eye and base assembly with headed anchor bolt, backer plate, lock washer, and nut.
2. Suitable for embedment in concrete wall or slab.

C. Manufacturers and Products:

1. Thaler Metal Industries, Buffalo, NY; FARA Wall Anchor.
2. Rose Manufacturing Company, Pittsburgh, PA; Anchorage Connector.

2.19 ALTERNATING STAIR TREADS

A. Material:

1. Landings, Treads, and Foot Castings: Cast aluminum alloy F356F.
2. Handrails: Aluminum alloy 6063-T4, 1-1/2-inch by 1/8-inch tube.

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3. Central Stringer: Aluminum alloy 6063-T52, 1-3/4-inch by 4-inch by 1/8-inch tube with rubber bumper strip.

B. Treads: Skid-resistant with upturned integrally cast skid barriers.

C. Risers: Equally spaced to within 3/16 inch for adjacent risers and to within 3/8 inch for nonadjacent risers.

D. Handrails: Contoured for body guidance and underarm support, with supports positioned to allow free sliding of hands along rails.

E. Foot Divider: Cast aluminum integral part of landing, which provides support for rubber bumper strip attached to central stringer.

F. Stair Angle: 68 degrees from horizontal.

G. Vertical Drop: As shown on Drawings.

H. Finish: Natural aluminum finish.

I. Manufacturer and Product: Lapeyre Stair, Inc., Harahan, LA; 68-Degree Alternating Tread Aluminum Stair.

2.20 FABRICATED UNITS

A. Weir and Baffle Plates: Fabricate plates and associated framing of stainless steel, AISI Type 316 unless indicated otherwise on Drawings.

2.21 CASTINGS

A. Meter Box Manhole: Nonslip surface and handle, as manufactured by Olympic Foundry Co.

2.22 ACCESSORIES

A. Antiseizing Lubricant for Stainless Steel Threaded Connections:

1. Suitable for potable water supply.
2. Resists washout.
3. Manufacturers and Products:
   a. Bostik, Middleton, MA; Neverseez.
   b. Saf-T-Eze Div., STL Corp., Lombard, IL; Anti-Seize.

B. Neoprene Gasket:

1. ASTM D1056, 2C1, soft, closed-cell neoprene gasket material, suitable for exposure to sewage and sewage gases, unless otherwise shown on Drawings.

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2. Thickness: Minimum 1/4 inch.
3. Furnish without skin coat.
4. Manufacturer and Product: Monmouth Rubber and Plastics Corporation, Long Branch, NJ; Durafoam DK1111LD.

2.23 FABRICATION

A. General:

1. Finish exposed surfaces smooth, sharp, and to well-defined lines.
2. Furnish necessary rabbets, lugs, and brackets so work can be assembled in neat, substantial manner.
3. Conceal fastenings where practical; where exposed, flush countersink.
4. Drill metalwork and countersink holes as required for attaching hardware or other materials.
5. Grind cut edges smooth and straight. Round sharp edges to small uniform radius. Grind burrs, jagged edges, and surface defects smooth.
6. Fit and assemble in largest practical sections for delivery to Site.

B. Materials:

1. Use steel shapes, unless otherwise noted.
2. Steel to be hot-dip galvanized: Limit silicon content to less than 0.04 percent or to between 0.15 percent and 0.25 percent.
3. Fabricate aluminum in accordance with AA Specifications for Aluminum Structures–Allowable Stress Design.

C. Welding:

1. Weld connections and grind exposed welds smooth. When required to be watertight, make welds continuous.
2. Welded fabrications shall be free from twisting or distortion caused by improper welding techniques.
3. Steel: Meet fabrication requirements of AWS D1.1/D1.1M, Section 5.
4. Aluminum: Meet requirements of AWS D1.2/D1.2M.
5. Stainless Steel: Meet requirements of AWS D1.6/D1.6M.
6. Welded Anchor Studs: Prepare surface to be welded and weld with stud welding gun in accordance with AWS D1.1/D1.1M, Section 7, and manufacturer’s instructions.
7. Complete welding before applying finish.

D. Painting:

1. Shop prime with rust-inhibitive primer as specified in Section 09 90 00, Painting and Coating, unless otherwise indicated.
2. Coat surfaces of galvanized steel and aluminum fabricated items to be in direct contact with concrete, grout, masonry, or dissimilar metals, as

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specified in Section 09 90 00, Painting and Coating, unless indicated otherwise.

3. Do not apply protective coating to galvanized steel anchor bolts or galvanized steel welded anchor studs, unless indicated otherwise.

E. Galvanizing:

1. Fabricate steel to be galvanized in accordance with ASTM A143/A143M, ASTM A384/A384M, and ASTM A385/A385M. Avoid fabrication techniques that could cause distortion or embrittlement of the steel.
2. Provide venting and drain holes for tubular members and fabricated assemblies in accordance with ASTM A385/A385M.
3. Remove welding slag, splatter, burrs, grease, oil, paint, lacquer, and other deleterious material prior to delivery for galvanizing.
4. Remove by blast cleaning or other methods surface contaminants and coatings not removable by normal chemical cleaning process in the galvanizing operation.
5. Hot-dip galvanize steel members, fabrications, and assemblies after fabrication in accordance with ASTM A123/A123M.
6. Hot-dip galvanize bolts, nuts, washers, and hardware components in accordance with ASTM A153/A153M. Oversize holes to allow for zinc alloy growth. Shop assemble bolts and nuts.
7. Galvanized steel sheets in accordance with ASTM A653/A653M.
8. Galvanize components of bolted assemblies separately before assembly. Galvanizing of tapped holes is not required.

F. Electrolytic Protection: Coat surfaces of galvanized steel and aluminum fabricated items to be in direct contact with concrete, grout, masonry, or dissimilar metals, as specified in Section 09 90 00, Painting and Coating, unless indicated otherwise.

G. Watertight Seal: Where required or shown, furnish neoprene gasket of a type that is satisfactory for use in **[A: contact with sewage] [B:].** Cover full bearing surfaces.

H. Fitting: Where movement of fabrications is required or shown, cut, fit, and align items for smooth operation. Make corners square and opposite sides parallel.

I. Accessories: Furnish as required for a complete installation. Fasten by welding or with stainless steel bolts or screws.

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2.24 SOURCE QUALITY CONTROL

A. Visually inspect all fabrication welds and correct deficiencies.

1. Steel: AWS D1.1/D1.1M, Section 6 and Table 6.1, Visual Inspection Acceptance Criteria.
2. Aluminum: AWS D1.2/D1.2M.
3. Stainless Steel: AWS D1.6/D1.6M.

B. Hot-Dip Galvanizing:

1. An independent testing agency shall be retained by Contractor and approved by Engineer to inspect and test hot-dip galvanized fabricated items in accordance with ASTM A123/A123M and ASTM A153/A153M.
2. Reject and retest nonconforming articles in accordance with ASTM A123/A123M and ASTM A153/A153M.

PART 3 EXECUTION

3.01 INSTALLATION OF METAL FABRICATIONS

A. General:

1. Install metal fabrications plumb and level, accurately fitted, free from distortion or defects.
2. Install rigid, substantial, and neat in appearance.
3. Install manufactured products in accordance with manufacturer’s recommendations.
4. Obtain Engineer approval prior to field cutting steel members or making adjustments not scheduled.

B. Aluminum:

1. Do not remove mill markings from concealed surfaces.
2. Remove inked or painted identification marks on exposed surfaces not otherwise coated after installed material has been inspected and approved.
3. Fabrication, mechanical connections, and welded construction shall be in accordance with the AA Aluminum Design Manual.

C. Pipe Sleeves:

1. Provide where pipes pass through concrete or masonry.
2. Holes drilled with a rotary drill may be provided in lieu of sleeves in existing walls.

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3. Provide center flange for water stoppage on sleeves in exterior or water-bearing walls.
4. Provide rubber caulking sealant or a modular mechanical unit to form watertight seal in annular space between pipes and sleeves.

D. Steel Lintels and Shelf Angles: Provide as required for support of masonry and other construction not attached to structural steel framing, unless otherwise shown on Drawings.

3.02 CAST-IN-PLACE ANCHOR BOLTS

A. Locate and hold anchor bolts in place with templates at time concrete is placed.

B. Use anchor bolt sleeves for location adjustment and provide two nuts and one washer per bolt of same material as bolt.

C. Minimum Bolt Size: 1/2-inch diameter by 12 inches long, unless otherwise shown.

3.03 U-CHANNEL CONCRETE INSERTS

A. Provide as indicated for pipe supports and where otherwise shown on Drawings.

B. Except for interior dry areas, use plastic clips or similar dielectric material to isolate channel anchors from concrete reinforcing steel.

3.04 ABRASIVE NOSINGS

A. Provide abrasive nosings on concrete steps not being supplied or coated with another type of nosing or nonskid material.

3.05 ACCESS COVERS

A. Install access covers, including sidewalk doors, floor hatches, and hinged manhole covers in accordance with manufacturer’s instructions.

B. Accurately position prior to placing concrete, such that covers are flush with floor surface.

C. Protect from damage resulting from concrete placement. Thoroughly clean exposed surfaces of concrete spillage to obtain a clean, uniform appearance.

D. Position cover so that hinge is on side opposite ladder.

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3.06 SAFETY CLIMB DEVICE SYSTEM

A. Provide for each ladder where unbroken height between levels exceeds 20 feet, or at lesser height where indicated on Drawings.

B. Install in accordance with manufacturer's instructions.

C. Furnish additional accessories required to complete system for each ladder.

D. Furnish one harness for each ladder equipped with safety climb device.

E. Furnish pivot section at platforms, landings, and roofs.

F. When installed to required height, fall prevention system shall be rigid and an integral part of the structure.

3.07 ELECTROLYTIC PROTECTION

A. Aluminum and Galvanized Steel:

1. Coat surfaces of galvanized steel and aluminum fabricated items to be in direct contact with concrete, grout, masonry, or dissimilar metals, as specified in Section 09 90 00, Painting and Coating, unless indicated otherwise.
2. Do not apply protective coating to galvanized steel anchor bolts or galvanized steel welded anchor studs, unless indicated otherwise.
3. Allow coating to dry before installation of the material.
4. Protect coated surfaces during installation.
5. Should coating become marred, prepare and touch up in accordance with paint manufacturer's written instructions.

B. Titanium: Where titanium equipment is in contact with concrete or dissimilar metal, provide full-face neoprene insulation gasket, 3/32-inch minimum thickness and 70-durometer hardness.

C. Stainless Steel:

1. During handling and installation, take necessary precautions to prevent carbon impregnation of stainless steel members.
2. After installation, visually inspect stainless steel surfaces for evidence of iron rust, oil, paint, and other forms of contamination.
3. Remove contamination using cleaning and passivation methods in accordance with requirements of ASTM A380 and ASTM A967.
4. Brushes used to remove foreign substances shall utilize only stainless steel or nonmetallic bristles.
5. After treatment, visually inspect surfaces for compliance.

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3.08 PAINTING

A. Painted Galvanized Surfaces: Prepare as specified in Section 09 90 00, Painting and Coating.

B. Repair of Damaged Hot-Dip Galvanized Coating:

1. Conform to ASTM A780/A780M.
2. For minor repairs at abraded areas, use sprayed zinc conforming to ASTM A780/A780M.
3. For flame cut or welded areas, use zinc-based solder, or zinc sticks, conforming to ASTM A780/A780M.
4. Use magnetic gauge to determine thickness is equal to or greater than base galvanized coating.

C. Field Painting of Shop Primed Surfaces: Prepare surfaces and field finish in accordance with Section 09 90 00, Painting and Coating.

3.09 FIELD QUALITY ASSURANCE AND QUALITY CONTROL

A. Owner-Furnished Quality Assurance:

1. In accordance with IBC Chapter 17 requirements, is provided in the Statement of Special Inspections Plan on Drawings.
2. Contractor responsibilities and related information on special inspection, observation, and testing are included in Section 01 45 33, Special Inspection, Observation, and Testing.

B. Contractor-Furnished Quality Control:

1. Inspection and testing required in Section 01 45 16.13, Contractor Quality Control.
2. Manufacturer’s Certificate of Compliance per Section 01 61 00, Common Product Requirements, for test results, or calculations, or drawings that ensure material and equipment design and design criteria meet requirements of Section 01 61 00, Common Product Requirements and Section 01 88 15, Anchorage and Bracing.

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3.10 FASTENER SCHEDULE

A. Unless indicated otherwise on Drawings, provide fasteners as follows:

Service Use and Location	Product	Remarks
1. Anchor Bolts Cast Into Concrete for Structural Steel, Metal Fabrications and Castings		
Interior Dry Areas	Hot-dip galvanized steel headed anchor bolts, unless indicated otherwise	
Exterior and Interior Wet Areas	Stainless steel headed anchor bolts	
Submerged and Corrosive Areas	Stainless steel headed anchor bolts with fusion bonded coating	See Section 09 90 00, Painting and Coating
2. Anchor Bolts Cast Into Concrete for Equipment Bases		
Interior Dry Areas	Hot-dip galvanized steel headed anchor bolts, unless otherwise specified with equipment	
Submerged, Exterior, Interior Wet, and Corrosive Areas	Stainless steel headed anchor bolts with fusion bonded coating, unless otherwise specified with equipment	See Section 09 90 00, Painting and Coating
3. Post-Installed Anchors: See Section 05 05 19, Post-Installed Anchors		
4. Anchors Cast in Grout-Filled Concrete Masonry Units		
Dry Areas	Hot-dip galvanized steel headed anchor bolts or zinc-plated steel sleeve anchors	
Exterior and Interior Wet Areas	Hot-dip galvanized steel headed anchor bolts, zinc-plated or stainless steel sleeve anchors	

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Service Use and Location	Product	Remarks
5. Connections for Structural Steel Framing		
Exterior and Interior Wet and Dry Areas	High-strength steel bolted connections	Use hot-dipped galvanized high-strength bolted connections for galvanized steel framing members.
6. Connections for Steel Fabrications and Wood Components		
Exterior and Interior Wet and Dry Areas	Stainless steel bolted connections	
7. Connections of Aluminum Components		
Submerged, Exterior and Interior Wet and Dry Areas	Stainless steel bolted connections, unless otherwise specified with equipment	
8. All Others		
Exterior and Interior Wet and Dry Areas	Stainless steel fasteners	

B. Antiseizing Lubricant: Use on stainless steel threads.

END OF SECTION

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SECTION 05 52 16
ALUMINUM RAILINGS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Aluminum Association, Incorporated (AA): DAF45, Designation System for Aluminum Finishes.
2. American Concrete Institute (ACI) 318, Building Code Requirements for Structural Concrete.
3. American Iron and Steel Institute (AISI).
4. ASTM International (ASTM):
    a. A193/A193M, Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
    b. A194/A194M, Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
    c. E894, Standard Test Method for Anchorage of Permanent Metal Railing Systems and Rails for Buildings.
    d. E935, Standard Test Methods for Performance of Permanent Metal Railing Systems and Rails for Buildings.
    e. E985, Standard Specification for Permanent Metal Railing Systems and Rails for Buildings.
5. International Code Council (ICC): International Building Code (IBC).
6. Occupational Safety and Health Act (OSHA): 29 CFR 1910, Code of Federal Regulations.

1.02 DEFINITIONS

A. ICC Evaluation Services Report: ICC report on evaluation of manufactured concrete anchor systems.

B. Railings: This term includes guardrail systems, handrail systems, platform railing systems, ramp-rail systems, and stair-rail systems. Railings may be comprised of a framework of vertical, horizontal, or inclined members, grillwork or panels, accessories, or combination thereof.

C. Special Inspection: As defined by the ICC IBC.

D. Toeboards: Vertical barrier at floor level usually erected on railings along exposed edges of floor or wall openings, platforms, or ramps to prevent miscellaneous items from falling through.

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1.03 DESIGN REQUIREMENTS

A. Structural Performance of Railing Systems: Design, test, fabricate, and install railings to withstand the following structural loads without exceeding allowable design working stress or allowable deflection. Apply each load to produce maximum stress and deflection in railing system components.

1. Railing System: Capable of withstanding the following load cases applied:
   a. Concentrated load of 200 pounds applied at any point and in any direction in accordance with ICC IBC and OSHA.
   b. Uniform load of 50 pounds per linear foot applied in any direction in accordance with ICC IBC.
   c. Concentrated load need not be assumed to act concurrently with uniform loads in accordance with ICC IBC.
2. Calculated lateral deflection at top of posts shall not exceed 1 inch.

1.04 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Project-specific scaled plans and elevations of railings and detail drawings. Include railing profiles, sizes, connections, anchorage, size and type of fasteners, and accessories.
   b. Manufacturer’s literature and catalog data of railing and components.
   c. Design Data: Calculations or test data using specified design performance loads and including the following:
      1) Bending stress in, and deflection of, posts in accordance with ASTM E985 as modified herein.
      2) Design of post base connection.
      3) Documentation that concrete anchors have been designed in accordance with one of the following:
         a) ACI 318, Appendix D.
         b) ICC Evaluation Services Report for selected anchor.

B. Informational Submittals:

1. Manufacturer’s assembly and installation instructions.
2. Special Inspection: Manufacturer’s instructions for Special Inspection of post-installed anchors.
3. Test Reports: Test data may supplement load calculations providing data covers complete railing system, including anchorage:
   a. Test data for railing and components showing load and deflection as a result of load, in enough detail to prove railing is strong enough and satisfies national, state, local standards, regulations,

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code requirements, and OSHA 29 CFR 1910, using design loads specified. Include test data for the following:

1) Railing and post connections.
2) Railing wall connections.
3) Railing expansion joint connections.
4) Railing system gate assembly, including latch, gate stop, and hinges. Both gate latch and stop to support required loads applied independent of each other.

b. Testing of anchorages shall be in accordance with ASTM E894 and ASTM E935 using applied loads in accordance with ICC IBC.

c. Deflection Criteria: In accordance with ASTM E985 and design loads specified, except as follows: maximum calculated lateral deflection at top of posts shall not exceed 1 inch.

d. Aluminum Rail Piping: Test data showing yield strength of pipe as delivered equals or exceeds specified values.

4. Manufacturer's written recommendations describing procedures for maintaining railings including cleaning materials, application methods, and precautions to be taken in use of cleaning materials.

1.05 QUALITY ASSURANCE

A. Qualifications: Calculations required for design data shall be stamped by a registered civil or structural engineer licensed in state where Project will be constructed.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Package and wrap railings to prevent scratching and denting during shipment, storage, and installation. Maintain protective wrapping to the extent possible until railing is completely installed.

B. Delivery:

1. Shop assemble into practical modules of lengths not exceeding 24 feet for shipment.
2. Deliver toeboards loose for field assembly.
3. Deliver clear anodized railing pipe and posts with protective plastic wrap.

1.07 ENVIRONMENTAL REQUIREMENTS

A. Thermal Movements: Allow for thermal movement resulting from the following maximum range in ambient temperature in design, fabrication, and installation of railings to prevent buckling, opening up of joints, over stressing of components, connections and other detrimental effects. Base design calculation on actual surface temperature of material as a result of both solar

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heat gain and night time sky heat loss. Temperature change is difference between high or low temperature and installation temperature.

1. Temperature Change Range: 70 degrees F, ambient; 100 degrees F, material surfaces.

PART 2 PRODUCTS

2.01 ALUMINUM RAILINGS

A. General:

1. Furnish pre-engineered and prefabricated railing systems as shown on Drawings.
2. Railing systems using pop rivets or glued railing construction are not permitted.
3. Sand cast accessories and components are not permitted.
4. Fasteners shall be AISI Type 316 stainless steel, unless otherwise noted.

B. Rails, Posts, and Formed Elbows:

1. Extruded Alloy 6105-T5, 6061-T6, or equivalent.
2. Tensile Strength: 38,000 psi, minimum.
3. Yield Strength: 35,000 psi, minimum.
4. Wall Thickness: 0.145 inch, minimum.
5. Posts and railings shall be nominal 1-1/2-inch diameter (1.90-inch outside diameter).

C. Accessories:

1. Fittings and Accessories:
   a. Extruded, machined bar stock, permanent mold castings, or die castings of sufficient strength to meet load requirements.
   b. Gauge metal components are not acceptable for load-resisting components.
   c. Fittings shall match color of pipe in railings.
2. Miscellaneous Extruded Aluminum Parts: Alloys 6063-T6, 6061-T6, or 6105 T5 aluminum, or equivalent, and of adequate strength for all loads.
3. Castings for Railings:
   a. Cast Al-mag with sufficient strength to meet load and test requirements.
   b. Anodizable grade finish with excellent resistance to corrosion when subjected to exposure of sodium chloride solution intermittent spray and immersion.

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4. Post Anchorages:
    a. Refer to standard details for types of post anchorages and minimum requirements.
    b. Bolts at anchorages shall be minimum 1/2-inch diameter.
5. Wall Brackets: Adjustable wall fitting, with provision for minimum three 3/8-inch diameter AISI Type 316 stainless steel bolts or concrete anchors.
6. Rail Terminals (including Wall Returns): Aluminum wall fitting with provision for three 3/8-inch Type 304 fasteners.
7. Railing System Gate:
    a. Extruded aluminum rail components.
    b. Hardware Manufacturers and Products:
        1) Julius Blum & Co., Inc., Carlstadt, NJ; No. 782/3 gate hinges with springs, and No. 784 gate latch and stop.
        2) CraneVeyor Corp., South El Monte, CA; No. C4370b gate hinges with spring, No. C4369 gate latch, and No. C4368 gate stop.
        3) Moultrie Manufacturing Co., Moultrie, GA; Part No. W60006.
8. Railing Picket Panels and Clamps:
    a. 1/2-inch Schedule 40 aluminum pipe (picket).
    b. Extruded aluminum 1-1/2-inch by 7/8-inch by 1/8-inch channel.
    c. Furnish neoprene plug for each end of picket.
    d. Fasteners: Stainless steel.
9. Toeboards:
    a. Molded or extruded Alloy 6063-T6 or 6061-T6 aluminum.
    b. Provide slotted holes for expansion and contraction where required.
10. Fasteners: Stainless steel.

D. Finishes:

1. Pipe and Post: In accordance with AA DAF45, designation AA-M32-C22-A41.
2. Cast Fittings and Toeboards: In accordance with AA DAF45, designation AA-M10-C22-A41.

2.02 ANCHOR BOLTS, FASTENERS, AND CONCRETE ANCHORS

A. Locknuts, Washers, and Screws:

1. Elastic Locknuts, Steel Flat Washers, Round Head Machine Screws (RHMS): AISI Type 316 stainless steel.
2. Flat Washers: Molded nylon.

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B. Bolts and Nuts for Bolting Railing to Metal Beams: ASTM A193/A193M and ASTM A194/A194M, Type 316 stainless steel.

C. Concrete Anchors:

1. Stainless steel, AISI Type 316.
2. Post-installed anchors in accordance with Section 05 50 00, Metal Fabrications, unless otherwise specified herein.
3. Bolt Diameter: 1/2-inch, minimum.

2.03 FABRICATION

A. Shop Assembly:

1. Post Spacing: Maximum 6-foot horizontal spacing.
2. Railing Posts Bolted to Metal or Concrete:
   a. In lieu of field cutting, provide approved fitting with sufficient post overlap, containing provisions for vertical adjustment.
   b. Field fit-up is required.
3. Free of burrs, nicks, and sharp edges when fabrication is complete.
4. Welding is not permitted.

B. Shop/Factory Finishing:

1. Use same alloy for uniform appearance throughout fabrication for railings.
2. Railing and Post Fittings: Match fittings with color of pipe in railing.

C. Shop Assembly:

1. Shop assemble rails, posts, and formed elbows with a close tolerance for tight fit.
2. Fit dowels tightly inside posts.

D. Repair of Defective Work: Remove stains and replace defective Work.

PART 3 EXECUTION

3.01 GENERAL

A. Field fabrication of aluminum railing systems is not permitted.

B. Where required, provide railing posts longer than needed and field cut to exact dimensions required in order to satisfy vertical variations on actual structure.

C. Install railing with base that provides plus or minus 1/4-inch vertical adjustment inside base fitting. If adjustment is required in field and exceeds

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plus or minus 1/4-inch, reduce post length not to exceed beyond bottom of lowest set-screw or bolt in base fitting.

D. Modification to supporting structure is not permitted where railing is to be attached.

E. Mount railings only on completed walls. Do not support railings temporarily by means not satisfying structural performance requirements.

F. Protection from Entrapped Water:

1. Make provisions in exterior and interior installations subject to high humidity to drain water from railing system.
2. For posts mounted in concrete, bends, and elbows occurring at low points, drill weep holes of 1/4-inch diameter at lowest possible elevations, one hole per post or rail. Drill hole in plane of rail.

3.02 RAILING INSTALLATION

A. Assembly and Installation: Perform in accordance with manufacturer's written recommendations for installation.

B. Expansion Joints:

1. Maximum intervals of 54 feet on center and at structural joints.
2. Slip joint with internal sleeve extending 2 inches beyond each side of joint. Provide 1/2-inch slip joint gap to allow for expansion.
3. Fasten to one side using 3/8-inch diameter set-screw. Place set-screw at bottom of pipe.
4. Locate joints within 12 inches of posts. Locate expansion joints in rails that span expansion joints in structural walls and floors supporting the posts.

C. Posts and Rails:

1. Surface Mounted Posts:
   a. Bolt post baseplate connectors firmly in place.
   b. Shims, wedges, grout, and similar devices for railing post alignment not permitted.
2. Set posts plumb and aligned to within 1/8 inch in 12 feet.
3. Set rails horizontal or parallel to slope of steps to within 1/8 inch in 12 feet.
4. Install posts and rails in same plane.
5. Remove projections or irregularities and provide a smooth surface for sliding hands continuously along top rail.
6. Use offset rail for use on stairs and platforms if post is attached to web of stringers or structural platform supports.

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7. Support 1-1/2-inch rails directly above stairway stringers with offset fittings.

D. Wall Brackets: Support wall rails on brackets spaced maximum 5 feet on centers as measured on the horizontal projection.

E. Toeboard:

1. Provide at railings, except where 4-inch or higher concrete curbs are installed, at gates, or at stairways unless shown otherwise.
2. Accurately measure in field for correct length; after railing post installation cut and secure to posts.
3. Dimension between bottom of toeboard and walking surface not to exceed 1/4 inch.
4. Install plumb and aligned to within 1/8 inch in 12 feet.

F. Railing System Gate: Install in accordance with manufacturer's installation instructions.

3.03 FIELD FINISHING

A. Corrosion Protection: Prevent galvanic action and other forms of corrosion caused from direct contact with concrete and dissimilar metals by coating metal surfaces as specified in Section 09 90 00, Painting and Coating.

3.04 FIELD QUALITY CONTROL

A. Post-installed anchors supporting railing systems require special inspection.

B. Owner-Furnished Quality Assurance, in accordance with ICC IBC Chapter 17 requirements, is provided in the Statement of Special Inspections Plan on Drawings. Contractor responsibilities and related information are included in Section 01 45 33, Special Inspection Observation, and Testing.

C. Contractor-Furnished Quality Control: Inspection and testing as required in Section 01 45 16.13, Contractor Quality Control.

3.05 CLEANING

A. Wash railing system thoroughly using clean water and soap. Rinse with clean water.

B. Do not use acid solution, steel wool, or other harsh abrasive.

C. If stain remains after washing, restore in accordance with railing manufacturer's recommendations or replace stained railings.

END OF SECTION

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SECTION 05 53 00
METAL GRATINGS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Association of State Highway and Transportation Officials (AASHTO): Standard Specifications for Highway Bridges.
2. ASTM International (ASTM):
   a. A36/A36M, Standard Specification for Carbon Structural Steel.
   b. A510, Standard Specification for General Requirements for Wire Rods and Coarse Round Wire, Carbon Steel.
   c. A666, Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar.
   d. A1011/A1011M, Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength.
   e. B221, Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes.
3. National Association of Architectural Metal Manufacturers (NAAMM):
   a. MBG 531, Metal Bar Grating Manual.
   b. MBG 532, Heavy-Duty Metal Bar Grating Manual.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Grating: Show dimensions, weight, size, and location of connections to adjacent grating, supports, and other Work.
   b. Grating Anchorage: Show details of anchorage to supports to prevent displacement from traffic impact.
   c. Product data for grating, grating clips, anchors, accessories, and other manufactured products specified herein.
   d. Manufacturer’s specifications, including coatings, surface treatment, and finishes.

B. Informational Submittals:

1. Special handling and storage requirements.
2. Installation instructions.

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1.03 DELIVERY, STORAGE, AND HANDLING

A. Insofar as is practical, factory assemble items.

B. Package and clearly tag parts and assemblies that are, due to necessity, shipped unassembled.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Materials, equipment, and accessories specified in this section shall be products of:

1. Alabama Metal Industries Corporation (AMICO), Birmingham, AL.
2. IKG Industries, Houston, TX.
3. Ohio Gratings, Inc., Canton, OH.
4. Seidelhuber Metal Products, Inc., South San Francisco, CA.

2.02 GRATING MATERIALS

A. Carbon Steel:

1. Bearing Bars, Banding, and Rectangular Cross Bars: ASTM A1011/A1011M commercial steel Type II for hot rolled carbon steel sheet and strip, or ASTM A36/A36M.
2. Cross Bars made from Wire Rods: Not Permitted.
3. Finish: Galvanized after fabrication.

2.03 METAL BAR GRATING

A. General Requirements:

1. Maximum Service Load:
   a. Light Duty (Type A): 100 psf uniformly distributed load.
   b. Medium Duty (Type B): 300 psf uniformly distributed load.
2. Maximum Deflection: Span/240 or 1/4 inch, whichever is less.
3. Bearing Bar Spacing:
   a. Light Duty: 1-3/16 inch maximum, center-to-center.
   b. Medium Duty: 15/16 inch maximum, center-to-center.
4. Cross Bar Spacing: 4 inches maximum, center-to-center.
5. Bearing Bars, Cross Bars and Banding: Minimum thickness as specified in NAAMM MBG 531 or as shown on Drawings.

B. Grating Materials: Galvanized steel welded, rectangular bar grating fabricated by electro-forging cross bars to bearing bars.

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C. Surface: Slip resistant, consisting of an applied abrasive finish of aluminum-oxide aggregate.

D. Stair Treads:

1. Material and Type: Same as grating material and grating type as furnished for connecting walkway or work surface.
2. Nosings: Integral ribbing and serrated edge on one long axis of tread, or nonslip abrasive on each tread along one long edge.
3. Carrier Plate or Angle: Furnish at each end for connection to stair stringers.

2.04 HEAVY-DUTY METAL BAR GRATING (TYPE C)

A. General Requirements:

1. Maximum Service Load: AASHTO H-20.
2. Maximum Deflection: Span/240.
3. Bearing Bar Spacing: 1-7/8 inch maximum center-to-center.
4. Cross Bar Spacing: 4 inches maximum center-to-center.
5. Bearing Bars, Cross Bars and Banding: Minimum thickness as specified in NAAMM MBG 532 or as shown on Drawings.
6. Grating Type: Galvanized steel, heavy-duty, rectangular bar grating fabricated by welding crossbars between rectangular bearing bars.

2.05 ACCESSORIES

A. Embedded Frames: As indicated on Drawings and as specified in Section 05 50 00, Metal Fabrications.

B. Grating Clamps:

1. Use at flanged beam and bolted angle frame supports.
2. Removable from above grating walkway surface.
3. Provide hat bracket, recessed bolt, and bottom clamp of same material as grating.
4. Manufacturers and Products:
   a. Direct Metals Company, LLC, Kennesaw, GA; Grating Clamp.
   b. Grating Fasteners, Inc., Harvey, LA; G-Clip.

C. Anchor Stud and Saddle Clip:

1. Use at embedded angle frame supports with stud anchor and nut recessed below top of grating surface.
2. Removable from above grating walkway surface.
3. Provide Type 316 stainless steel welded threaded stud anchor, nut, washer, and saddle clip.

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4. Manufacturers and Products:
    a. Welded Stud Anchor:
        1) Nelson Stud Welding, Inc., Elyria, OH.
        2) Stud Welding Associates, Inc. Elyria, OH.
    b. Saddle Clip:
        1) Direct Metals Company, LLC, Kennesaw, GA; Saddle Clip.
        2) Grating Fasteners, Inc., Harvey, LA; Saddle Clip.
        3) Struct-Fast, Inc., Baltimore, MD; Gratefast.

2.06 FABRICATION

A. General:

1. In accordance with NAAMM MBG 531 or NAAMM MBG 532.
2. Do not weld aluminum grating.
3. Conceal fastenings where practical.
4. Drill metalwork and countersink holes as required for attaching hardware or other materials.
5. Cutouts:
    a. Fabricate in grating sections for penetrations indicated.
    b. Arrange to permit grating removal without disturbing items penetrating grating.
    c. Edge band openings in grating that interrupt four or more bearing bars with bars of same size and material as bearing bars.
6. Do not notch bearing bars at supports to maintain elevation.
7. Field measure areas to receive grating. Verify dimensions of new fabricated supports, and fabricate to dimension required for specified clearances.
8. Section Length: Sufficient to prevent section from falling through clear opening when oriented in the span direction and one end is touching either the concrete or the vertical leg of grating support.
9. Minimum Bearing: 1 inch for grating depth up to 2-1/4 inches and 2 inches for grating depth greater than 2-1/4 inches.
10. Banding and Toe Plates: Same material as grating and welded to bearing bars in accordance with requirements of NAAMM MBG 531 and NAAMM MBG 532.

B. Metal Bar Grating: A single grating section shall be not less than 1.5 feet or greater than 3 feet in width, or weigh more than 150 pounds.

C. Heavy Duty Metal Bar Grating: Minimum width of grating sections shall be 2 feet regardless of length and weight.

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D. Supports:

1. Same material as grating, except that supports which are to be embedded in concrete shall be Type 316 stainless steel, unless part of an extruded aluminum system.
2. Coordinate dimensions and fabrication with grating to be supported.

PART 3 EXECUTION

3.01 PREPARATION

A. Electrolytic Protection: Allow paint to dry before installation of material.

3.02 INSTALLATION

A. Until grating sections are securely fastened in place, area shall be appropriately barricaded or flagged to alert people working in the area of potential fall hazard.

B. Install manufactured products in accordance with manufacturer's recommendations.

C. Install supports such that grating sections have a solid bearing on both ends, and that grating sections will not rock or wobble under design loads.

D. Install grating supports plumb and level as applicable.

E. Install sections of welded frames with anchors to straight plane without offsets.

F. Field locate and install fasteners to fit grating layout.

G. Anchor grating securely to supports using minimum of four fastener clips and bolts per grating section.

H. Each grating or plank section shall be easily removable and replaceable.

I. Completed installation shall be rigid and neat in appearance.

J. Protect painted and galvanized surfaces during installation.

K. Repair damaged coatings as specified in Section 09 90 00, Painting and Coating.

END OF SECTION

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SECTION 06 10 00
ROUGH CARPENTRY

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Wood Council (AWC): 2, National Design Specification for Wood Construction.
2. American Hardboard Association (AHA): A135.4, Basic Hardboard.
3. American Institute of Timber Construction (AITC): 112, Standard for Tongue-and-Groove Heavy Timber Roof Decking.
4. American Lumber Standards Committee's Board of Review (ALSC).
5. American Wood Preservers' Association (AWPA):
   a. U1, User Specification for Treated Wood.
   b. M4, Standard for the Care of Preservative-Treated Wood Products.
6. ASTM International (ASTM):
   a. A153/A153M, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
   b. A307, Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60,000 PSI Tensile Strength.
   c. A653/A653M, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
   d. D3498, Standard Specification for Adhesives for Field-Gluing Plywood to Lumber Framing for Floor Systems.
   e. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
   f. F1667, Standard Specification for Driven Fasteners: Nails, Spikes, and Staples.
7. Forest Stewardship Council (FSC), Principles and Criteria for Forest Stewardship, Version 4-0 (STD 01 001).
8. International Code Council (ICC):
   a. ESR-1539, Power-Driven Staples and Nails.
   b. International Building Code (IBC).
9. National Fire Protection Association (NFPA): 255, Standard Method of Test of Surface Burning Characteristics of Building Materials.
10. Underwriters' Laboratories, Inc. (UL): 723, Standard for Test for Surface Burning Characteristics of Building Materials.

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11. U.S. Department of Commerce—Voluntary Product Standard (DOC):
    a. PS 1, Structural Plywood.
    b. PS 2, Performance Standard for Wood-Based Structural-Use Panels.
12. Western Wood Products Association (WWPA): G5, Western Lumber Grading Rules.

1.02 DEFINITIONS

A. AHA: American Hardboard Association.

B. ALSC: American Lumber Standards Committee's Board of Review.

C. AWC: American Wood Council.

D. CPA: Composite Panel Association.

E. DOC: Department of Commerce.

F. SPIB: Southern Pine Inspection Bureau.

1.03 SUBMITTALS

A. Informational Submittals:

1. ICC Evaluation Service Reports, including the following as a minimum:
    a. Connections and Fasteners.
    b. Wood Treatment.
    c. Nails.
    d. Wood Nailers.
2. Wood treatment manufacturer's instructions for handling, storing, installation, and finishing of treated material.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Upon delivery to Site, immediately place materials in area protected from weather. Do not store seasoned materials in wet or damp areas.

B. Protect sheet materials from breaking corners and damaging surfaces while unloading.

C. Store materials a minimum of 6 inches above ground on framework or blocking and cover with waterproof covering, providing for adequate air circulation and ventilation. Store sheet materials flat, not on edge.

D. For lumber and plywood pressure treated with waterborne chemicals, place spacers between each bundle to provide air circulation.

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E. Store materials for which maximum moisture content is specified in areas where humidity can be controlled.

PART 2 PRODUCTS

2.01 GENERAL

A. Lumber Standards:

1. In accordance with DOC PS 20 and applicable grading rules and wood species certified by ALSC.
2. Design values for wood members equal to those published in supplement to AWC 2.
3. Stamp or brand each unexposed piece of lumber with grade, species, and moisture content at time of mill surfacing.

B. Lumber sizes shown on Drawings are nominal, unless shown otherwise. Provide actual sizes as required by DOC PS 20 for use.

C. Moisture content of lumber not to exceed 19 percent, unless otherwise specified and marked “DRY”.

D. Each plywood panel identified with designated grade trademark of APA.

2.02 LUMBER

A. Framing Lumber: Douglas Fir-Larch, No. 1 or better unless indicated otherwise below:

Usage	Minimum Grade
Blocking, furring, braces, and nailers	Douglas Fir-Larch No. 2, Hemlock, Southern Pine Stud grade, nondense

2.03 CONSTRUCTION PANELS

A. Plywood Backing Panel: Mounting electrical, telephone, and like equipment; provide fire-retardant treated plywood panel with grade designation, APA C-D Plugged Exposure 1, in thickness shown on Drawings, or, if not shown on Drawings, not less than 15/32 inch.

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2.04 PRESERVATIVE WOOD TREATMENT BY PRESSURE PROCESS

A. Where lumber or plywood is indicated as preservative-treated wood, in accordance with AWPA U1 and AWPA M4, mark and grade each treated item in accordance with SPIB 1003 or WWPA G5.

1. Kiln-dry after treatment to maximum moisture content of 19 percent.
2. Treat wood in contact with roofing or flashing.
3. Treat wood in contact with masonry or concrete.
4. Treat wood less than 18 inches above grade.

B. Aboveground Materials:

1. Pressure treat items with waterborne preservatives to a minimum retention of 0.25 per cubic foot.
2. Interior Use: After treatment, kiln-dry lumber and plywood to maximum moisture content of 19 percent and 15 percent respectively.
3. Treat the following items:
    a. Wood cants, nailers, curbs, equipment support bases, blocking, stripping, and similar members in connection with roofing, flashing, vapor barriers, and waterproofing.
    b. Wood sills, sleepers, blocking, furring, stripping, and similar concealed members in contact with masonry or concrete.
    c. Wood framing members less than 18 inches above grade.
    d. Wood floor plates installed over concrete slabs directly in contact with earth.

C. Complete fabrication of treated items prior to treatment, where possible. If cut after treatment, coat cut surfaces to comply with AWPA M4. Inspect each piece of lumber or plywood after drying and discard damaged or defective pieces.

2.05 HARDWARE

A. Fasteners and connectors in contact with preservative-treated wood shall be hot-dipped zinc-coated galvanized steel or stainless steel in accordance with ASTM A153/A153M.

B. Conform to ASTM F1667.

C. Nails:

1. Conform to ASTM F1667.
2. Steel common nails or alternatives listed in rough carpentry section of General Structural Notes found on Drawings.
3. Use hot-dipped zinc-coated nails wherever exposed.

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D. Power Driven Fasteners: Conform to ICC ESR-1539.

E. Bolts and Screws: Conform to ASTM A307, galvanized where exposed.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify surfaces to receive rough carpentry materials are prepared to exact grades and dimensions.

3.02 GENERAL

A. Lay out, cut, fit, and install rough carpentry items. Anchor sufficiently to ensure rigidity and permanence.

B. Install items accurate to dimension, true to line, level, and square unless shown otherwise on Drawings. Provide for installation and support of other Work.

C. Discard units of material with defects that impair quality of rough carpentry construction and that are too small to use in fabricating rough carpentry with minimum joints or optimum joint arrangement.

D. Countersink nailheads on exposed carpentry work and fill holes.

E. Make provisions for temporary construction loads, and provide temporary bracing sufficient to maintain structure in true alignment and safe condition until completion of erection and installation of permanent bracing.

F. Field treat field cuts and holes in pressure-treated lumber with preservative in accordance with AWPA M4.

G. Holes: 1/16 inch larger than nominal bolt diameter, except provide holes for cast-in-place anchor bolts 3/16 inch larger than nominal bolt diameter.

1. Enlarge tight holes requiring forcible driving of bolts by reaming.

H. Provide washers under bolt heads and nuts bearing on wood.

3.03 INSTALLATION

1. Blocking:
   a. Install in continuous, staggered horizontal row where shown on Drawings or required by code.
   b. Locate blocking to facilitate installation of finishing materials, fixtures, specialty items, hardware, and trim.

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3.04 PRESERVATIVE-TREATED WOOD PRODUCTS

A. Provide preservative-treated wood for framing, blocking, furring, nailing strips built into exterior masonry walls, wood in contact with concrete or masonry and in conjunction with gravel stops, and built-up roofing.

B. Apply two brush coats of same preservative used in original treatment to sawed or cut surfaces of treated lumber.

END OF SECTION

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SECTION 06 41 00
ARCHITECTURAL WOOD CASEWORK

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Architectural Woodwork Institute Quality Certification Corporation (AWI QCC): Quality Certification Program.
2. Architectural Woodwork Institute, Architectural Woodwork Manufacturers Association of Canada, Woodwork Institute (AWI, AWMAC, WI): Architectural Woodwork Standards.
3. Builders Hardware Manufacturers Association (BHMA):
   a. 156.9, Cabinet Hardware.
   b. 156.11, Cabinet Locks.
4. Federal Specifications (FS): A-A-1936, Adhesive, Contact, Neoprene Rubber.
5. Hardwood Plywood and Veneer Association (HPVA): HP-1, Hardwood and Decorative Plywood.
6. National Electrical Manufacturers' Association (NEMA): LD 3, High-Pressure Decorative Laminates (HPDL).
7. Woodwork Institute (WI): Certified Compliance Program (CCP).

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Show details and dimensions not controlled by job conditions and required field measurements.
   b. Describe and illustrate features of design showing field measurements, construction details, dimensions, materials, and finish.
      1) Use full-size or 1/4-size scale drawings.
      2) Key to Contract Drawings.
   c. Furnish manufacturer's descriptive literature of specialty items not manufactured by woodwork manufacturer.
2. Samples: Each finish to be applied by woodwork manufacturer.

B. Informational Submittals: Proof of woodwork manufacturer qualifications.

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1.03 QUALITY ASSURANCE

A. Manufacturer's Qualifications:

1. Successful completion of comparable work on similar size project within 2 years before start of construction on this Project.
2. Quality Standards: AWI, AWMAC, WI Architectural Woodwork Standards.

B. Casework and Paneling:

1. Reference to Premium, Custom, or Economy Grade: As defined in AWI, AWMAC, WI Architectural Woodwork Standards.
2. Provide Custom Grade, unless otherwise specified.

C. Cabinet Hardware: In accordance with BHMA 156.9 and BHMA 156.11.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Defer delivery to Site until installation and storage areas are complete and dry of wet type construction, and excessive moisture has been out of building for at least 10 days.

B. Protect casework and paneling from damage and dampness. Store in weathertight, well-ventilated areas. Do not subject to extreme changes of temperature or humidity.

1.05 ENVIRONMENTAL REQUIREMENTS

A. For a minimum of 72 hours prior to installation, allow woodwork to come to equilibrium onsite in space where it is to be installed.

B. Humidity: For 24 hours before, during, and after installation, maintain relative humidity between 25 percent and 55 percent.

C. Temperature: For 24 hours before, during, and after installation, maintain ambient temperature between 65 degrees F and 75 degrees F.

PART 2 PRODUCTS

2.01 CASEWORK FINISH

A. Plastic Laminate:

1. Meet requirements of AWI, AWMAC, WI Architectural Woodwork Standards Section 10.

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2. Furnish casework exposed surfaces, including top, edges, front face, and backsplashes, with plastic laminate in colors indicated in Interior Finish Schedule.

2.02 CASEWORK HARDWARE

A. Hinges: For conventional flush without face frames, use European style hinge; 626 finish.

1. Manufacturers:
   a. Blum, Inc.
   b. Grass America, Inc.
   c. Stanley.

B. Pulls: Solid brass or bronze, Stanley No. 4484, Baldwin No. 4676; 626 satin chrome finish.

C. Heavy-Duty Drawer Slides: Knape and Vogt No. 1429 or Grant No. 4930.

D. Heavy-Duty Shelf Supports: Knape and Vogt slotted standard No. 82 and bracket No. 182; or Stanley No. 6783 and 6785, clear anodized aluminum finish.

2.03 PLASTIC LAMINATE

A. General Use and Paneling: NEMA LD 3, Grade GP 38; in colors indicated in Interior Finish Schedule.

2.04 SOLID SURFACING

A. Materials:

1. Solid Polymer Components:
   a. Cast, non-porous, filled polymer, not coated, laminated, or of composite construction with through body colors meeting ANSI Z 124.3 or ANSI Z 124.6.
   b. Superficial damage to a depth of 0.010 inch shall be repairable by sanding or polishing.
2. Thickness: 1/2 inch and tripled for 1-1/2 inch edges.
3. Finish: Matte, gloss range of 5 to 20.
4. Colors: As shown on the Color List and Finish schedules on the Drawings.

B. Manufacturer and Product:

1. Dupont / Corian.
2. WilsonArt / Solid Surface.

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2.05 ANCILLARY MATERIALS

A. Adhesives: Plastic Laminate: Contact cement; FS A-A-1936.

B. Hardware: Furnish fasteners and miscellaneous hardware required for assembling and anchoring woodwork, including casework.

2.06 FABRICATION

A. Moisture Content: Kiln dry lumber to an average moisture content range as follows:

1. Exterior Work: 9 percent to 15 percent.
2. Interior Work: 5 percent to 10 percent.

B. Casework Construction: AWI, AWMAC, WI Architectural Woodwork Standards Section 10, Custom Grade, flush overlay as shown on the Drawings.

C. Casework Fronts: Plastic laminate.

D. Casework Units: Shop assembled for field installation.

E. Install concealed hinges on doors.

F. Drawer Slides: Use side-mounted, heavy-duty type.

G. Install casework hardware in accordance with manufacturer's instructions.

1. Provide items where indicated and as required for a complete installation.
2. Provide pulls and catches on casework doors.

PART 3 EXECUTION

3.01 PREPARATION

A. Examine grounds, stripping, and blocking for cabinet attachment.

B. Do not proceed to install until conditions are acceptable to installer.

C. Verify surfaces to receive architectural woodwork items are properly prepared.

3.02 CASEWORK INSTALLATION

A. Coordinate installation of, and cut openings for mechanical, electrical, and other items that penetrate casework surfaces and tops.

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B. Install casework in true alignment, level, and plumb.

C. Secure units with nails or screws to cleats that have been anchored to building structure or wall framing.

D. Install wall-hung cabinets to rigidly support cabinet weight plus normally expected weight of cabinet contents.

E. Accurately scribe and closely fit faceplates, filler strips, and trim strips to irregularities of adjacent surfaces.

F. Adhere plastic laminate as recommended by laminate manufacturer.

1. Apply with as few cross joints as possible and no longitudinal joints.
2. Scribe neatly to vertical surfaces.

G. Toe Space at Front of Cabinets: Provide by installing front face of cabinets 3 inches in front of base face.

3.03 SOLID SURFACING INSTALLATION

A. Factory Fabrication:

1. Shop Assembly:
   a. Fabricate components to greatest extent practical to sizes and shapes indicated, in accordance with approved Shop Drawings and manufacturer's printed instructions and technical bulletins.
   b. Form joints between components using manufacturer's standard joint adhesive without conspicuous joints.
      1) Reinforce with strip of solid polymer material, 2 inches wide.
   c. Route and finish component edges with clean, sharp returns.
      1) Route cutouts, radii, and contours to template.
      2) Smooth edges.
      3) Repair or reject defective and inaccurate work.

B. Examination: Examine substrates and conditions, with fabricator present for compliance with requirements for installation tolerances and other conditions affecting performance of work. Field verify all dimensions.

C. Installation: Install components plumb, level and rigid, scribed to adjacent finishes, in accordance with approved Shop Drawings and product data.

1. Provide product in the largest pieces available.
2. Form field joints using manufacturer's recommended adhesive, with joints inconspicuous in finished work.
   a. Exposed joints/seams shall not be allowed.

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3. Reinforce field joints with solid surface strips extending a minimum of 1-inch on either side of the seam with the strip being the same thickness as the top.
4. Cut and finish component edges with clean, sharp returns.
5. Route radii and contours to template.
6. Anchor securely to wall or other supports.
7. Align adjacent countertops and form seams to comply with manufacturer's written recommendations using adhesive in color to match countertop.
8. Carefully dress joints smooth, remove surface scratches, and clean entire surface.

3.04 ADJUSTING AND CLEANING

A. Adjust hardware and leave in smooth working condition.

B. Adjust doors and drawers to operate without restriction.

C. Surfaces: Clean and ready for use.

D. Staining or Discoloration of Finish: Restore to original finish or replace unit.

END OF SECTION

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SECTION 07 14 00
FLUID-APPLIED WATERPROOFING

PART 1 GENERAL

1.01 SUBMITTALS

A. Action Submittals:

1. Shop Drawings: Copies of manufacturer's literature for products proposed.

1.02 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to Project Site in sealed, undamaged containers. Identify each container with material name, date of manufacture, and lot number.

B. Store material in dry area out of direct sunlight. Storage area temperature shall not exceed 90 degrees F.

1.03 ENVIRONMENTAL REQUIREMENTS

A. Perform Work only when existing and forecasted weather conditions are within limits established by manufacturer of materials and products used.

B. Proceed with installation only when substrate construction and preparation work is complete and in condition to receive waterproofing.

PART 2 PRODUCTS

2.01 MEMBRANE

A. Polyurethane elastomer-based fluid applied waterproofing membrane.

B. Manufacturers and Product:

1. Gaco Western, Seattle, WA; LM-60.
2. Sonneborn a Division of BASF, Shakopee, MN; HLM 5000.
3. W.R. Grace & Co., Cambridge, MA; Procor 20.

2.02 RELATED MATERIALS

A. As follows, compatible with components produced by membrane manufacturer:

1. Primers: As recommended by membrane manufacturer for type of substrate involved.

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2. Sealants: Low modulus, unmodified polyurethane or as recommended by membrane manufacturer.
3. Flashing Reinforcement: Woven, uncoated fiberglass mesh on 0.050-inch thick precured neoprene.
4. Protection Board: Rigid Insulation as specified in Section 07 21 00, Thermal Insulation and as approved by membrane manufacturer.

PART 3 EXECUTION

3.01 CONDITIONS OF SURFACES

A. Verify curing methods used for concrete are compatible with membrane system.

3.02 PREPARATION

A. Cleaning:

1. Thoroughly clean surfaces to receive membrane following membrane manufacturer's recommendations.
2. Treat as necessary to remove laitance, loose material on surface, grease, oil, and other contaminants that will affect bond of the membrane.
3. Vacuum clean or clear water wash surfaces and allow to dry completely.

B. Fill voids and control joints with sealant and overcoat with nonflow membrane material. Fill or coat visible shrinkage cracks to minimum 2 inches either side of crack.

C. Use drop cloths or masking as required for protection of adjacent surfaces.

3.03 FLASHINGS-FLUID APPLIED

A. Unless Drawings establish more restrictive requirements, the following minimum requirements apply:

1. Fill construction joint voids at intersections of vertical and horizontal walls with backer rod and sealant in accordance with requirements of membrane manufacturer.
2. Nonreinforced Flashing:
   a. Install nonreinforced flashing at construction joints not subject to movement, at all intersecting surfaces that are structurally and rigidly connected, and at all piping or other penetrations through membraned surface that do not require reinforced flashing.
   b. Apply 50-mil minimum dry film thickness of membrane for 4 inches minimum onto adjacent surfaces.
   c. At intersections of membrane with vertical walls, piping penetrations, and at projections through horizontal membrane,

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extend flashing coat to a height not greater than finished horizontal surface, with due allowance for installation of sealant work. Trowel a 1-inch-high, 45-degree cant at meeting angle using nonflowing membrane material.

d. At projections through a vertical membrane, extend flashing coat 4 inches minimum onto penetrating element.

3. Reinforced Flashing:

a. Apply flashing reinforcement over cracks, expansion and control joints, and at changes of plane where adjacent surfaces are not structurally and rigidly connected and also at penetrations through a membrane surface.

b. Apply 50-mil dry film thickness embedment coat of membrane to surfaces to be flashed. Extend 6 inches minimum out onto adjacent deck surface.

c. Embed reinforcement in wet coating. Embedment coating should extend 2 inches beyond reinforcement.

d. At intersections of membrane with vertical walls, extend embedment coat and reinforcement to a height not greater than finished horizontal surface with due allowance for installation of sealant work. Trowel a 1-inch high, 45-degree cant at meeting angle using nonflowing coating material.

3.04 MEMBRANE

A. Install, following safety and weather conditions required by manufacturer or as modified by applicable rules and regulations of federal, state, and local authorities having jurisdiction.

B. Following manufacturer’s instructions, apply membrane material with a calibrated notched squeegee, trowel, or approved spray equipment to produce a 50-mil minimum dry thickness.

C. Extend membrane over previously flashed areas.

D. Use self-leveling membrane material up to a 5 percent slope.

E. Use nonflow membrane material for vertical surfaces and surfaces over a 5 percent slope.

F. Allow membrane to cure overnight. At temperatures less than 75 degrees F and relative humidities less than 50 percent, extend curing time.

3.05 PROTECTION

A. Protect cured vertical membranes exposed to backfilling operations with protection board.

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B. Butt all boards; do not overlap.

C. Adhere or bond protection boards to membrane as recommended by membrane manufacturer.

3.06 CLEANING

A. Clean stains from adjacent surfaces with toluene, 1-1-1, trichloroethane, xylene, commercial tar remover, or as recommended by the membrane manufacturer.

B. Remove foreign matter from finished membrane surface.

3.07 APPLICATION SCHEDULE

A. Membrane:

1. Apply waterproofing membrane and protection board to exterior surfaces of cast-in-place concrete structures below finish ground level that enclose spaces that may be occupied, such as stairways, galleries, pump rooms, mechanical and electrical equipment rooms, and other areas shown on Drawings. Do not include water-holding basins.
2. Apply membrane from top of footings to 6 inches below finished grade.

END OF SECTION

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SECTION 07 21 00
THERMAL INSULATION

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   a. C303, Standard Test Method for Dimensions and Density of Preformed Block and Board-Type Thermal Insulation.
   b. C578, Standard Specification for Rigid, Cellular Polystyrene Thermal Insulation.
   c. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
   d. E96/E96M, Standard Test Methods for Water Vapor Transmission of Materials.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings: Manufacturer’s product literature identifying products proposed for use.

1.03 DELIVERY, STORAGE, AND HANDLING

A. On packaging clearly identify manufacturer, contents, brand name, applicable standard, and R-value.

B. Store materials off ground and keep them dry. Protect against weather, condensation, and damage.

PART 2 PRODUCTS

2.01 RIGID INSULATION

A. Extruded Polystyrene Foam:

1. ASTM C578, Type IV.
2. Flame Spread: Less than 25 when tested in accordance with ASTM E84.
3. R-Value: As shown on Drawings.

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4. Manufacturers and Products:
    a. Dow Chemical Co.; Styrofoam Square Edge.
    b. UC Industries; Foamular.

B. Adhesives and Fasteners: As recommended by insulation manufacturer.

PART 3 EXECUTION

3.01 RIGID INSULATION

A. Install in accordance with the following:

1. Install boards in location and in R-value as shown.
2. Cut insulation with saw, knife, or other sharp tool to fit tightly around obstructions.
3. Butt insulation boards together tightly at joints.
4. Where thickness required exceeds 1-1/2 inches, install two layers of boards.
5. Apply to concrete or membrane with adhesive recommended by insulation manufacturer:
    a. Follow manufacturer's recommendations for preparing surfaces and applying adhesive.

END OF SECTION

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SECTION 07 26 16
BELOWGRADE VAPOR RETARDERS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Concrete Institute (ACI): 302, Guide for Concrete Floor and Slab Construction.
2. ASTM International (ASTM):
   a. D412, Standard Test Method for Vulcanized Rubber and Thermoplastic Elastomers – Tension.
   b. D882, Standard Test Method for Tensile Properties of Thin Plastic Sheeting.
   c. D903, Standard Test Method for Peel or Stripping Strength of Adhesive Bonds.
   d. D1709, Standard Test Methods for Impact Resistance of Plastic Film by the Free-Falling Dart Method.
   e. D3767, Standard Practice for Rubber – Measurement of Dimensions.
   f. D4833, Standard Test Method for Index Puncture Resistance of Geomembranes and Related Products.
   g. E96/E96M, Standard Test Methods for Water Vapor Transmission of Materials.
   h. E154, Standard Test Methods for Water Vapor Retarders Used in Contact with Earth Under Concrete Slabs, on Walls, or a Ground Cover.
   i. E1643, Standard Practice for Installation of Water Vapor Retarders Used in Contact with Earth or Granular Fill under Concrete Slabs.
   j. E1745, Standard Specification for Plastic Water Vapor Retarders Used in Contact with Soil or Granular Fill under Concrete Slabs.
   k. F1249, Standard Test Method for Water Vapor Transmission Rate Through Plastic Film and Sheeting Using a Modulated Infrared Sensor.

1.02 SUBMITTALS

A. Action Submittals: Manufacturer’s material specifications.

1.03 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials in labeled packages. Store and handle in strict compliance with manufacturer’s instructions. Protect from damage from weather,

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excessive temperature and construction operations. Remove and dispose of damaged material in accordance with applicable regulations.

PART 2 PRODUCTS

2.01 UNDERSLAB VAPOR RETARDER

A. Meet or exceed ASTM E1745, Class A, with the following properties:

1. Water Vapor Permeance: 0.03 perm maximum when tested in accordance with ASTM E96/E96M or ASTM F1249.
2. Tensile Strength: 45-foot-pounds per inch minimum, when tested in accordance with ASTM D882.
3. Puncture Resistance: 2,200 grams minimum, when tested in accordance with ASTM D1709.
4. Thickness: 10 mils minimum, in accordance with ACI 302.

B. Manufacturers and Products:

1. Fortifiber Building Systems Group; Moistop Ultra 10.
2. Reef Industries, Inc.; Griffolyn 10 mil Green.
3. Stego Industries, LLC; Stego Wrap Class A Vapor Retarder.

2.02 ANCILLARY MATERIALS

A. Fasteners, Tape, Adhesive, or Sealant: As recommended by vapor retarder manufacturer.

B. Pipe Boots: Manufacturer’s recommended prefabricated or field fabricated item.

PART 3 EXECUTION

3.01 PREPARATION

A. Examine conditions of substrates and other conditions under which work is to be performed. Do not proceed with work until satisfactory conditions are obtained.

3.02 INSTALLATION

A. Underslab Vapor Retarder:

1. Apply in accordance with manufacturer’s instructions.
2. After base for slab has been leveled and tamped, apply vapor retarder with roll width parallel to direction of concrete pour.
3. Lap vapor retarder over footings and seal to foundation walls.
4. Overlap joints 6 inches and seal with tape.

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5. Seal penetrations with pipe boots.
6. Repair damaged areas with patches of vapor retarder, overlapping damaged area by 6 inches and sealing sides of patch with tape.

3.03 CLEANING

A. Upon completion of vapor retarder installation, remove waste materials and debris resulting from this operation and dispose offsite.

END OF SECTION

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SECTION 07 62 00
SHEET METAL FLASHING AND TRIM

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   a. A153/A153M, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
   b. A653/A653M, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
   c. A666, Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar.
   d. A924/A924M Standard Specification for General Requirements for Steel Sheet, Metallic-Coated by the Hot-Dip Process.
   e. B32, Standard Specification for Solder Metal.
   f. B209, Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
   g. B370, Standard Specification for Copper Sheet and Strip for Building Construction.
   h. C920, Standard Specification for Elastomeric Joint Sealants.
   i. C1311, Standard Specification for Solvent Release Sealants.
   j. D1187/D1187M, Standard Specification for Asphalt-Base Emulsions for Use as Protective Coatings for Metal.
   k. D4586/D4586M, Standard Specification for Asphalt Roof Cement, Asbestos-Free.
2. Federal Specifications (FS): QQ-L-201F(2), Lead Sheet.
3. FM Global (FM): Loss Prevention Data Sheet 1-49, Perimeter Flashing.
4. Sheet Metal and Air Conditioning Contractors National Association (SMACNA): 1793, Architectural Sheet Metal Manual.

1.02 PERFORMANCE REQUIREMENTS

A. General: Sheet metal flashing and trim shall withstand wind loads, structural movement, thermally induced movement, and exposure to weather without failing, rattling, leaking, and fastener disengagement.

B. Thermal Movements:

1. Provide sheet metal flashing and trim that allows for thermal movements resulting from the following maximum change (range) in ambient and surface temperatures for preventing buckling, opening of

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joints, hole elongation, overstressing of components, failure of joint sealants, failure of connections, and other detrimental effects.
a. Temperature Change (Range): 120 degrees F, ambient; 180 degrees F, material surfaces.

2. Provide clips that resist rotation and avoid shear stress as a result of sheet metal and trim thermal movements.
3. Base engineering calculation on surface temperatures of materials as a result of both solar heat gain and nighttime-sky heat loss.

C. Water Infiltration: Provide sheet metal flashing and trim that does not allow water infiltration to building interior.

1.03 QUALITY ASSURANCE

A. Sheet Metal Flashing and Trim Standard: Comply with SMACNA 1793. Conform to dimensions and profiles shown, unless more stringent requirements are indicated.

1.04 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
a. Show joints, types and location of fasteners, and special shapes.
b. Catalog data for stock manufactured items.
2. Samples: Color Samples for items to be factory finished.

1.05 DELIVERY, HANDLING, AND STORAGE

A. Inspect for damage, dampness, and wet storage stains upon delivery to Site.

B. Remove and replace damaged or permanently stained materials that cannot be restored to like-new condition.

C. Carefully handle to avoid damage to surfaces, edges, and ends.

D. Do not open packages until ready for use.

E. Store materials in dry, weathertight, ventilated areas until immediately before installation.

PART 2 PRODUCTS

2.01 METAL

A. Galvanized Sheet Steel: ASTM A924/A924M, Grade A or ASTM A653/A653M, G90 zinc coating, commercial quality copper bearing

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steel, thickness 0.0239-inch (24 U.S. Standard gauge), unless otherwise shown.

B. Prefinished Galvanized Steel Sheet: ASTM A924/A924M, Grade A or ASTM A653/A653M, G90 zinc coating; 24-gauge (0.02-inch) core steel, shop prefinished with fluoropolymer coating (Kynar polyvinylidene fluoride resin) coating; color as scheduled in Exterior Finish Schedule.

2.02 ANCILLARY MATERIALS

A. Sealing Tape: Polyisobutylene sealing tape.

B. Isolation Paint: As specified in Section 09 90 00, Painting and Coating.

C. Isolation Tape: Butyl or polyisobutylene, internally reinforced, or 20-mil thick minimum polyester.

D. Plastic Roof Cement: ASTM D4586/D4586M, Type II.

E. Elastomeric Sealant: ASTM C920, elastomeric silicone polymer sealant; of type, grade, class, and use classifications required to seal joints in sheet metal flashing and trim and remain watertight.

F. Butyl Sealant: ASTM C1311, single-component, solvent-release butyl rubber sealant, polyisobutylene plasticized, heavy bodied for hooked-type expansion joints with limited movement.

G. Fasteners:

1. Galvanized Steelwork: Steel, galvanized per ASTM A153/A153M or stainless steel fasteners.
2. Zinc or Aluminum Work: Stainless steel or aluminum; reglet fasteners may be galvanized or cadmium-plated steel.
3. Stainless Steelwork: Stainless steel.
4. Copperwork: Copper or copper alloy.
5. Nails: Roofing nailhead, 10-gauge spiral or ring shank, lengths as required to penetrate wood at least 3/4 inch or as required in Article Performance Requirements.

2.03 FABRICATION OF FLASHING

A. Field measure prior to fabrication.

B. Fabricate in accordance with SMACNA 1793 that applies to design, dimensions, metal, and other characteristics of item indicated.

1. Roof Penetration Flashings: Figures 4-13, 4-14, 4-15, 4-16, and 4-17.

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C. Fabricate sheet metal flashing and trim in thickness or weight needed to comply with performance requirements, but not less than that specified for each application and metal.

D. Fabricate sheet metal flashing and trim without excessive oil canning, buckling, and tool marks and true to line and levels indicated, with exposed edges folded back to form hems.

E. Seams:

1. Aluminum: Fabricate nonmoving seams with flat-lock seams. Form seams and seal with epoxy seam sealer. Rivet joints for additional strength.
2. Other Than Aluminum: Fabricate nonmoving seams in accessories with flat-lock seams. Tin edges to be seamed, form seams, and solder.

F. Reinforcements and Supports: Provide same material as flashing, unless other material is shown. Steel, where shown or required, shall be galvanized or stainless.

G. Rigid Joints and Seams: Make mechanically strong.

H. Sealed Joints: Form nonexpansion but movable joints in metal to accommodate elastomeric sealant to comply with SMACNA recommendations.

I. Expansion Provisions: Where lapped or bayonet-type expansion provisions in the Work cannot be used, form expansion joints of intermeshing hooked flanges, not less than 1-inch deep, filled with butyl sealant concealed within joints.

J. Fabricate sheet metal in 10-foot maximum lengths, unless otherwise indicated.

K. Provide watertight closures at exposed ends of counterflashing.

L. Fabricate corners in one-piece with legs extending 30 inches each way to field joint. Lap, rivet, or solder corner seams watertight. Apply sealant if necessary.

M. Fabricate cleats and attachment devices from same material as accessory being anchored or from compatible, noncorrosive metal.

1. Thickness: As recommended by SMACNA 1793 and FM Loss Prevention Data Sheet 1-49 for application, but not less than thickness of metal being secured.

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PART 3 EXECUTION

3.01 EXAMINATION

A. Verify roof openings, curbs, pipes, sleeves, ducts, or vents through roof are solidly set and cant strips and reglets in place.

B. Verify nailing strips and blocking are properly located.

C. Verify membrane termination and base flashings are in place, sealed, and secure.

3.02 INSTALLATION

A. Flashing:

1. General:
   a. Install sheet metal roof flashing and trim to comply with performance requirements and SMACNA 1793.
   b. Provide concealed fasteners where possible, set units true to line, and level as indicated.
   c. Install work with laps, joints, and seams that will be permanently watertight.
2. Isolate metal from wood and concrete and from dissimilar metal with isolation tape or two coats of isolation paint.
3. Use only stainless steel fasteners to connect isolated dissimilar metals.
4. Joints: 10-foot maximum spacing and 2-1/2 feet from corners, butted with 3/16-inch space centered over matching 8-inch-long backing plate with sealing tape in laps.
5. Set flanges of flashings and roof accessories on continuous sealing tape or in plastic roof cement on top of envelope ply of roofing. Nail flanges through sealing tape and at 3-inch maximum spacing. Touch up isolation paint on flanges.
6. Joints, Fastenings, Reinforcements, and Supports: Sized and located as required to preclude distortion or displacement as a result of thermal expansion and contraction.
7. Provide continuous holddown clips at counterflashing and gravel stops.
8. Conceal fastenings wherever possible.
9. Set flashing and sheet metal to straight, true lines with exposed faces aligned in proper plane without bulges or waves.
10. At vents through roof turn down lead flashing minimum 2 inches inside vent pipe.

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3.03 FINISH

A. Exposed Surfaces of Flashing and Sheet Metalwork: Free of dents, scratches, abrasions, or other visible defects, and clean and ready for painting where applicable.

3.04 CLEANING AND PROTECTION

A. Clean exposed metal surfaces of substances that interfere with uniform oxidation and weathering.

B. Clean and neutralize flux materials. Clean off excess solder and sealants.

C. Remove temporary protective coverings and strippable films as sheet metal flashing and trim are installed. On completion of installation, clean finished surfaces, including removing unused fasteners, metal filings, pop rivet stems, and pieces of flashing. Maintain in a clean condition during construction.

D. Replace sheet metal flashing and trim that have been damaged or that have deteriorated beyond successful repair by finish touchup or similar minor repair procedures.

END OF SECTION

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SECTION 07 70 01
ROOF SPECIALTIES AND ACCESSORIES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Air Movement and Control Association International (AMCA).
2. American Architectural Manufacturers Association (AAMA).
3. ASTM International (ASTM):
   a. D1187, Standard Specification for Asphalt-Base Emulsions for Use as Protective Coatings for Metal.
   b. D4586, Standard Specification for Asphalt Roof Cement, Asbestos-Free.
4. FM (Factory Mutual) Global (FM).
5. Underwriters Laboratories, Inc. (UL).

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings of each item specified showing materials, details, flashing, anchorage, and relation to adjacent structure.
2. Catalog cuts of each item specified item.

B. Informational Submittals: Manufacturer's Certificate of Compliance per Section 01 61 00, Common Product Requirements, (or alternately, test results or calculations) that assure item's and its anchorage's design criteria meets requirements of Section 01 88 15, Anchorage and Bracing, for loads provided in Section 01 61 00, Common Product Requirements.

1.03 SEQUENCING AND SCHEDULING

A. Coordination: Schedule and coordinate work of this section with work of Section 13 34 19, Metal Building Systems and Section 07 62 00, Sheet Metal Flashing and Trim.

PART 2 PRODUCTS

2.01 METAL BUILDING ROOF CURBS

A. Prefabricated Galvanized Steel: Minimum 8-inch-high curb with treated wood nailer, liner panel, integral water deflecting cricket, loose cell caps, and factory-installed insulation as required for conditions shown on Drawings.

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B. Metal Gauge and Reinforcement: To suit imposed loads of equipment to be supported.

C. Fabricate curbs with level tops, with flanges surface mounted over metal building roof panels.

D. Fabricate cell caps to conform to profile of standing seam of approved metal building roof panels.

E. Manufacturers and Products:

1. Pate Co.; Model PC-2MB-3.
2. ThyCurb; Model TC-3 MBD.
3. RPS Corporation; RC-7.

2.02 FLEXIBLE BASE PIPE SEALS

A. Prefabricated one-piece aluminum flanged base with stepped, graduated EPDM cap and adjustable stainless steel clamps. Aluminum base shall be capable of bending to match profile of sheet metal roofing panels.

B. Manufacturers and Products:

1. Pate Co.; Dektite.
2. Portals Plus, Inc.; Deck-Mate.

2.03 ROOF HATCHES

A. Material: Galvanized steel, 14-gauge with factory-insulated curb suited for metal roof specified, integral drainage cricket, and locking cover.

B. Manufacturers and Products:

1. Size: 4 feet by 4 feet:
   a. Bilco; Type F.
   b. Or approved equal.

2.04 SNOW GUARDS

A. Manufacturers and Products:

1. Snowblox; Ace or Deuce model.
2. Zaleski; Model No. 15.
3. Berger Bros. Co.; AP, SM, or RTCLSM.
4. M.J. Mullane Co.; Model 640.

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2.05 ANCILLARY MATERIALS

A. Sealing Tape:

1. Polyisobutylene sealing tape Isolation Paint: As specified in Section 09 90 00, Painting and Coating.

B. Plastic Roof Cement: ASTM D4586, Type II.

C. Fasteners: Stainless steel of type required.

PART 3 EXECUTION

3.01 PREPARATION

A. Examine surfaces and structures to receive the Work of this section.

B. Take measurements at Site and fabricate work to suit. No changes shall be made in supporting structure to accommodate this Work.

3.02 INSTALLATION

A. General:

1. Install roof specialties and accessories as detailed in approved shop drawings and in conformance with manufacturer's instructions, recommendations, and standards.
2. Use appropriate pipe curb assembly, pipe seal, flexible base pipe seal, or vent pipe flashing where pipe, conduit, or cable, etc., penetrate roofing membrane.
3. Factory Finished Units: Place color variations in pieces so no extremes are next to each other.
4. Make Work weathertight and free of expansion and contraction noise.
5. Maintain separation between aluminum surfaces and concrete or dissimilar metals as specified in Section 09 90 00, Painting and Coating.

B. Roof Hatches: Install to operate freely and not rattle when closed or open.

C. Snow Guards:

1. Locate where shown on Drawings.
2. Install in strict accordance with manufacturer's written instructions, including recommended spacing for roof type, slope, and location, and attachment method.

END OF SECTION

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SECTION 07 92 00
JOINT SEALANTS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   a. C661, Standard Test Method for Indentation Hardness of Elastomeric Type Sealants by Means of a Durometer.
   b. C834, Standard Specification for Latex Sealants.
   c. C920, Standard Specification for Elastomeric Joint Sealants.
   d. C1193, Standard Guide for Use of Joint Sealants.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings: Surface preparation instructions. Indicate where each product is proposed to be used.
2. Samples: Material proposed for use showing color range available.

1.03 ENVIRONMENTAL REQUIREMENTS

A. Ambient Temperature: Between 40 degrees F and 80 degrees F (4 degrees C and 27 degrees C) when sealant is applied. Consult manufacturer when sealant cannot be applied within these temperature ranges.

PART 2 PRODUCTS

2.01 SEALANT MATERIALS

A. Characteristics:

1. Uniform, homogeneous.
2. Free from lumps, skins, and coarse particles when mixed.
3. Nonstaining, nonbleeding.
4. Hardness of 15 minimum and 50 maximum, measured by ASTM C661 method.
5. Immersible may be substituted for nonimmersible.

B. Color: Unless specifically noted, match color of the principal wall material adjoining area of application and as selected by Engineer.

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C. Type 1—Silicone, Nonsag, Nonimmersible:

1. Silicone base, single-component, moisture curing; ASTM C920, Type S, Grade NS, Class 25.
2. Capable of withstanding movement up to 50 percent of joint width.
3. Manufacturers and Products:
   a. Dow Corning Corp.; No. 790.
   b. General Electric; Silpruf.
   c. BASF; Sonneborn, Omniseal-50.

D. Type 2—Multipart Polyurethane, Self-leveling, Immersible:

1. Polyurethane base, multicomponent, chemical curing; ASTM C920, Type M, Grade P, Class 25.
2. Capable of being continuously immersed in water.
3. Manufacturers and Products:
   a. BASF; Sonneborn, SL-2.
   b. Pecora Corp.; Urexspan NR-200.
   c. Tremco; THC-900/901.
   d. Sika Chemical Corp.; Sikaflex 2c SL.

E. Type 3—Multipart Polyurethane, Nonsag, Immersible:

1. Polyurethane base, multicomponent, chemical curing; ASTM C920, Type M, Grade NS, Class 25.
2. Capable of being continuously immersed in water.
3. Manufacturers and Products:
   a. Pecora; DynaTrol II.
   b. Tremco; Dymeric 240.
   c. BASF; Sonneborn NP-2.
   d. Sika Chemical Corp.; Sikaflex 2c NS.

F. Type 4—Multipart Polyurethane, Nonsag, Nonimmersible:

1. Polyurethane base, multicomponent, chemical curing; ASTM C920, Type M, Grade NS, Class 25.
2. Manufacturers and Products:
   a. BASF; Sonneborn NP-2.
   b. Pecora Corp.; Dynatrol II.
   c. Tremco; Dymeric 240.
   d. Sika Chemical Corp.; Sikaflex 2c NS.

G. Type 5—One-part Polyurethane, Immersible:

1. Polyurethane base, single-component, moisture curing; ASTM C920, Type S, Grade NS or P, Class 25.

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2. Capable of being continuously immersed in water.
3. Manufacturers and Products for Nonsag:
    a. Sika Chemical Corp.; Sikaflex-1a.
    b. Tremco; Vulkem 116.
4. Manufacturers and Products for Self-leveling:
    a. BASF; Sonneborn, SL-1.
    b. Tremco; Vulkem 45.
    c. Sika Chemical Corp.; Sikaflex 1c SL.

H. Type 6—One-Part Polyurethane, Nonimmersible:

1. Polyurethane base, single-component, moisture curing; ASTM C920, Type S, Grade NS, Class 25.
2. Manufacturers and Products:
    a. Pecora Corp.; Dynatrol 1 XL.
    b. Tremco; Dymonic.
    c. BASF; Sonneborn, NP-I.

I. Type 10—Sanitary Sealant:

1. Silicone sealant similar to Type 1, above, formulated to resist mold growth and repeated exposure to high humidity while retaining adhesion, flexibility, and color.
2. Manufacturers and Products:
    a. Dow Corning; 786.
    b. General Electric; Sanitary Sealant SCS1700.

J. Type 11—Fire Penetration Seal:

1. Manufacturers and Products:
    a. 3M Corp.; Fire Barrier Caulk CP25 and Putty 303.
    b. General Electric; Pensil Sealant or Foam.
    c. Unifrax Corporation; Fyre Putty.
    d. Hilti USA; CP 604.

2.02 BACKUP MATERIAL

A. Nongassing, extruded, closed-cell round polyurethane foam or polyethylene foam rod, compatible with sealant used, and as recommended by sealant manufacturer.

B. Size: As shown or as recommended by sealant material manufacturer. Provide for joints greater than 3/16 inch wide.

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C. Manufacturers and Products:

1. Sonneborn; Sonolastic Closed-cell Backing Rod.
2. Tremco; Closed-cell Backing Rod.
3. Pecora Corporation; Green Rod.

2.03 ANCILLARY MATERIALS

A. Bond Breaker: Pressure sensitive tape as recommended by sealant manufacturer to suit application.

B. Joint Cleaner: Noncorrosive and nonstaining type, recommended by sealant manufacturer; compatible with joint forming materials.

C. Primer: Nonstaining type recommended by sealant manufacturer to suit application.

PART 3 EXECUTION

3.01 GENERAL

A. Use of more than one material for the same joint is not allowed unless approved by sealant manufacturer.

B. Install joint sealants in accordance with ASTM C1193.

C. Horizontal and Sloping Joints up to 1 Percent Maximum Slope: Use self-leveling (Grade P) joint sealant.

D. Steeper Sloped Joints, Vertical Joints, and Overhead Joints: Use nonsag (Grade NS) joint sealant.

E. Use joint sealant as required for the applicable application and as follows:

Joint Size	Sealant Type
Less than 1"	1, 2, 3, 4, 5, 6, or 10
Less than 2"	1, 2, 3, or 4
Over 2"	Follow manufacturer’s recommendation

3.02 PREPARATION

A. Verify that joint dimensions, and physical and environmental conditions, are acceptable to receive sealant.

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B. Surfaces to be sealed shall be clean, dry, sound, and free of dust, loose mortar, oil, and other foreign materials.

1. Mask adjacent surfaces where necessary to maintain neat edge.
2. Starting of work will be construed as acceptance of subsurfaces.
3. Apply primer to dry surfaces as recommended by sealant manufacturer.

C. Verify joint shaping materials and release tapes are compatible with sealant.

D. Examine joint dimensions and size materials to achieve required width/depth ratios.

E. Follow manufacturer’s instructions for mixing multi-component products.

3.03 INSTALLATION

A. Use joint filler to achieve required joint depths, to allow sealants to perform intended function.

1. Install backup material as recommended by sealant manufacturer.
2. Where possible, provide full length sections without splices; minimize number of splices.
3. Tape sealant may be used as joint filler if approved by sealant manufacturer.

B. Use bond breaker where recommended by sealant manufacturer.

C. Seal joints around window, door and louver frames, expansion joints, control joints, and elsewhere as indicated.

D. Joint Sealant Materials: Follow manufacturer’s recommendation and instructions, filling joint completely from back to top, without voids.

E. Joints: Tool slightly concave after sealant is installed.

1. When tooling white or light color sealant, use a water wet tool.
2. Finish joints free of air pockets, foreign embedded matter, ridges, and sags.

3.04 CLEANING

A. Clean surfaces next to the sealed joints of smears or other soiling resultant of sealing application.

B. Replace damaged surfaces resulting from joint sealing or cleaning activities.

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3.05 JOINT SEALANT SCHEDULE

A. This schedule lists the sealant types acceptable for each joint location. Use as few different sealant types as possible to meet the requirements of Project.

Joint Locations	Sealant Type(s)
Expansion/Contraction and Control Joints At:	
Concrete Walls (except water-holding and belowgrade portions of structures)	1, 3, 4, 5, 6
Concrete Floor Slabs (except for water-holding Structures)	2, 5
Slabs Subject to Vehicle and Pedestrian Traffic	2, 5
Masonry Walls	1, 3, 4, 5, 6
Ceramic Tile Floors	1, 2, 5
Ceramic Tile Walls	1, 3, 5
Material Joints At:	
Metal Door, Window, and Louver Frames (Exterior)	1, 5, 6
Metal Door, Window, and Louver Frames (Interior)	1, 5, 6
Wall Penetrations (Exterior)	1, 5, 6
Wall Penetrations (Interior)	1, 5, 6
Floor Penetrations	5, 6
Ceiling Penetrations	1, 3, 4, 5, 6
Roof Penetrations	5
Sheet Metal Flashings	5
Sheet Metal Roofing and Siding	5
Other Joints:	
Threshold Sealant Bed	5
Between Counter Tops and Backsplashes	10
Around Plumbing Fixtures	10

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Joint Locations	Sealant Type(s)
Openings Around Pipes, Conduits, and Ducts Through Fire-Rated Construction	11
Openings and gaps at tops and or edges of Fire-Rated partitions and walls.	11

B. Use sealant Type 11 to seal voids and holes around penetrations through fire-rated elements.

END OF SECTION

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SECTION 08 11 00
METAL DOORS AND FRAMES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American National Standards Institute (ANSI):
   a. A250.6, Hardware on Standard Steel Doors (Reinforcement - Application).
   b. A250.8, Recommended Specification for Standard Steel Doors and Frames.
   c. A250.11, Recommended Erection Instructions for Steel Frames.
2. ASTM International (ASTM):
   a. A480/A480M, Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip.
   b. A653/A653M, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
   c. A1008/A1008M, Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardenable.
   d. E90, Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements.
   e. F1233-98 Standard Test Method for Security Glazing Materials And Systems.
3. Builders Hardware Manufacturers Association (BHMA): A156.115, Hardware Preparations in Standard Steel Doors and Frames.
4. National Fire Protection Association (NFPA): 80, Standard for Fire Doors and Other Opening Protectives.
5. Underwriters Laboratories, Inc. (UL): Building Materials Directory.
   a. UL752 Standard for Bullet Resisting Equipment – Level 4.

1.02 SUBMITTALS

A. Action Submittals:

1. Applicable information for each type of door and frame, including:
   a. Frame conditions and complete anchorage details, supplemented by suitable schedules covering doors and frames.
   b. Glass and louver opening sizes and locations in doors.

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c. Connections of door frames to structural steel framing concealed in frames.
d. Location and field splice joints for frames too large to ship in one piece; indicate complete instructions for making field splices.
e. Joints required to accommodate expansion joint movement.
f. Relate to door numbers used in Contract Drawings.
g. Manufacturer's Literature for Bullet Resistant Doors and Frames:
    1) Clearly marked for products used on this project.
    2) Documentation that products meet performance level specified.

1.03 DELIVERY, STORAGE, AND HANDLING

A. Properly identify each item with number used in Contract Drawings.

B. Store doors upright, in protected dry area, at least 1 inch off ground or floor and at least 1/4 inch between individual pieces.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Materials, equipment, and accessories specified in this section shall be products of:

1. Curries Manufacturing.
2. Assa Abloy - Ceco Door.
3. Republic Steel Corp.
4. Steelcraft Manufacturing Co.

2.02 MATERIALS

A. Basic Metal Material: ASTM A1008/A1008M; sheet steel, cold-rolled, stretcher level.

B. Hollow Metal Frames:

1. Products of hollow metal door manufacturer.
2. ANSI 250.8, except as modified herein.
3. Frames for Doors and Windows: 16 gauge for interior and 14 gauge with thermal break, for exterior, welded type, of cross-section shown.
4. Prepare floor and wall anchors, reinforcement, and cutouts for hardware to meet requirements of BHMA A156.115 and ANSI A250.6.
5. Finished size, shape, and profile of frame members as shown.
6. Concealed fasteners or welding are preferred to through-the-face fasteners.

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7. Identification: Stamp opening number, as shown on Drawings, on center hinge reinforcement of each frame.

C. Hollow Metal Doors: ANSI A250.8, except as modified herein. BHMA A156.115 and ANSI A250.6 to receive hardware specified in Door and Hardware Schedule.

1. Interior:
   a. Flush Panel Doors: 18 gauge, Level 2, Model 2.
   b. Stile and Rail Doors: 16 gauge, Level 3, Model 3.
   c. Flush end closure at top of doors.
2. Exterior:
   a. Flush Panel Doors: 16 gauge, Level 3, Model 2.
   b. Stile and Rail Doors: 16 gauge, Level 3, Model 3.
   c. Double Doors: Overlapping astragals for active leaf, except as noted or detailed otherwise.
   d. Flush end closure at top of doors.
   e. R-Value: R-7.

D. Labeled Fire Doors and Frames:

1. Conform to listing requirements of Underwriters Laboratories, Inc. (UL).
2. Label each door and frame for class of rating required.
3. Label requirements, dimensions, and type of door are indicated in Door and Hardware Schedule. on Drawings.
   a. Modify drawing details if required to secure label.
   b. Clearly identify modifications on Shop Drawings.
   c. Maximum temperature rise of 450 degrees F for stairway enclosures.

E. Bullet Resistant Doors and Frames:

1. Hollow metal doors and frames as specified above except provide 14 gauge seamless doors, frames with no thermal break, and bullet resistant armor core.
2. Performance Level;
   a. Bullet Resistance Tested: Meet requirements of UL752 – Level 4.
   b. Ammunition Tested: Rifle.30 caliber lead core, 180 grain, minimum 2450 feet per second.
3. Manufacturer and Product: Assa Abloy Ceco Door; Armor Shield Level 4.

F. Glazing:

1. Doors: Furnish with formed flush-type glazing strips with butt corner joints to permit selection of secure side in field.

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2. Glazing Arrangements: Accommodate glass of type and thickness indicated and as specified in Section 08 80 00, Glazing.

2.03 MISCELLANEOUS ITEMS

A. Transom Panels: Furnish of same construction and finish as door to include fire-resistive label and sound-retardant construction.

B. Furnish manufacturer's standard core filler, anchors, fasteners, and other ancillary items.

2.04 FACTORY FINISHING REQUIREMENTS

A. Galvanized with A60 zinc coating in accordance with ASTM A653/A653M (Wipe Coat galvanized coating is not acceptable).

B. Phosphate treat metal for paint adhesion.

C. One shop coat of baked-on rust-inhibiting prime coating compatible with finish coating as shown and as specified in Section 09 90 00, Painting and Coating.

PART 3 EXECUTION

3.01 INSTALLATION

A. Frames:

1. Follow ANSI A250.11 and manufacturer's instructions.
   a. Maintain scheduled dimensions, hold head level, and maintain jambs plumb and square.
   b. Secure anchorages and connections to adjacent construction.
   c. Wherever possible, leave frame spreader bars intact until frames are set perfectly square and plumb and anchors are securely attached.

B. Doors:

1. Hollow Metal Doors: ANSI A250.8.
2. Hardware: In accordance with manufacturer's templates and instructions.
   a. Adjust operable parts for correct function.
   b. Remove hardware, with exception of prime coated items, tag, box, and reinstall after finish paint work is completed.
3. Labeled Doors: NFPA Pamphlet No. 80.
4. Bullet Resistant Doors and Frames: Follow door manufacturer's installation instructions conforming to performance level specified.

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3.02 FIELD PAINTING

A. Where prime coat has been damaged, sand smooth and touch up with same primer as applied at shop.

1. Remove rust before painting.
2. Touch Up: Not obvious.
3. Perform immediately after door and frame installation.

3.03 PROTECTION

A. Protect installed doors and frames against damage from other construction work.

3.04 SCHEDULES

A. For tabulation of door and frame characteristics, such as size, type, detail, and finish hardware requirements, see Door and Hardware Schedule on Drawings.

END OF SECTION

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SECTION 08 30 00
SPECIALTY DOORS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Iron and Steel Institute (AISI).
2. American Society of Mechanical Engineers (ASME): Boiler and Pressure Vessel Code, Section VIII, Division 1, Appendix VIII.
3. ASTM International (ASTM):
   a. A36/A36M, Standard Specification for Carbon Structural Steel.
   b. A653, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
   c. C1363, Standard Test Method for Thermal Performance of Building Materials and Envelope Assemblies by Means of a Hot Box Apparatus.
4. National Electrical Manufacturers' Association (NEMA): 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
5. National Fire Protection Association (NFPA): 70, National Electrical Code.
6. Underwriters Laboratories, Inc. (UL): Building Materials Directory.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Shop Drawings showing construction and installation details, and electrical characteristics and control diagrams for motor operators.
   b. Identify each door with same reference as used on Drawings.
2. Samples: 3 each, 2 inches by 3 inches with representative curtain material and Manufacturer's factory finished coating in color selected and shown on the Drawings.

1.03 QUALITY ASSURANCE

A. Qualifications: Experienced, factory authorized installer.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver doors with separators and wrapping to protect units from damage during and after installation.

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B. Store doors in protected dry area following manufacturer's requirements.

C. Handle doors according to manufacturer's instructions.

D. Protect exposed finish surfaces of prefinished items with wrapping.

PART 2 PRODUCTS

2.01 OVERHEAD COILING DOORS

A. Manufacturers:

1. Cornell Iron Works, Inc.
2. Kinnear, Division of Wayne-Dalton Corp.
3. Overhead Door Corp.

B. Design Requirement: Complete assembly, each component and anchorage to building to withstand a wind load of 30 pounds per square foot.

C. Insulated Curtain: Interlocking insulated flat slats of 20-gauge (U.S. Standard) minimum steel with minimum R-value of 8 and backing to match face slat thermally separated from face slat.

D. Hood: Match curtain material and finish.

E. Slide Guides: ASTM A36/A36M steel, shapes as appropriate for conditions.

F. Brackets, Gears, and Barrel: Manufacturer's standard items.

G. Operation:

1. Where noted in the Door and Hardware Schedule on the Drawings, provide motor operated worm and gear to chain drive with pushbutton stations and endless chain for emergency operation. Motor, UL listed and rated 460 volts, three-phase.
2. Where noted in the Door and Hardware Schedule on the Drawings, provide Manual Chain operated doors.
3. Provide NEMA 250 Type 1, general purpose enclosures for operator controls and stations at motor operated doors.
4. Where motor operated doors are located in hazardous areas, as noted in the Area Classification Table on Electrical Drawings, provide motors, controls, electric wiring and equipment meeting requirements of NFPA 70 for location hazard classification noted.

H. Locking: At manual chain operated doors, provide manufacturer's standard slide bolt locking mechanism.

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I. Finish:

1. Steel Curtain Slats, Guides, Hood, and Brackets: Hot-dip galvanize with G90 zinc coating in accordance with ASTM A653, phosphate treat for paint adhesion, followed by manufacturer's standard powder coat finish in color as shown in the Door and Hardware Schedule on the Drawings.

J. Special Features:

1. Bottom Bar:
   a. Provide galvanized steel bottom bar with flexible weatherstripping astragal on exterior doors.
   b. Finish to match curtain slats.
   c. Provide limit switch and automatic stop and reversing feature in astragal at motor operated doors.
2. End Locks and Wind Locks:
   a. Ends of each slat shall have end locks of material compatible with curtain.
   b. Provide wind locks at ends of every other slat minimum on exterior doors.
3. Weather Seals:
   a. Provide rubber, neoprene, or vinyl water seal at hood to prevent airflow around coil on exterior doors.
   b. Provide weather seal sealing strip on guide to close space between guide and curtain on exterior doors.

2.02 ACCESS DOORS

A. Manufacturers:

1. J.L. Industries, Bloomington, MN.
2. Milcor Inc., Lima, OH.
3. J. R. Smith, Montgomery, AL.

B. Manufactured Unit: Flush panel access doors and frames with anchors to suit ceiling and wall conditions.

C. Size: Smallest standard size permitting ready access and removal of working parts, but not less than 12 inches square.

D. Door: 16-gauge minimum stainless steel.

E. Frames: One-piece 16-gauge minimum stainless steel with 3/4-inch minimum exposed flange to cover edge of wall finish.

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F. Hinges: Spring-loaded concealed hinges permitting a minimum of 160-degree door travel and door removal.

G. Locks: Flush screwdriver operated.

H. Finish: AISI SS 201, No. 4.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install special doors in accordance with the manufacturer's recommendations and printed instructions.

B. Provide pushbutton operators inside doors.

C. Adjust doors for smooth, satisfactory operation.

3.02 FOLDING **[A: DOOR] [B: PARTITION]** INSTALLATION

A. Level track and fasten securely to header as recommended by manufacturer.

B. Install partition in accordance with manufacturer's instructions.

C. Adjust and leave partition in smooth operating condition without any indication of binding.

3.03 ACCESS DOOR INSTALLATION

A. Install access panels at cleanouts, valves, or other equipment requiring adjustment or servicing concealed within wall, furred spaces, or ceilings.

3.04 PROTECTION

A. Protect installed doors against damage from other construction work.

3.05 SCHEDULE

A. For tabulation of door and frame characteristics, such as size, type, detail, and finish hardware requirements, see Door and Hardware Schedule on Drawings.

END OF SECTION

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SECTION 08 45 00
TRANSLUCENT WALL AND ROOF ASSEMBLIES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Architectural Manufacturers Association (AAMA):
   a. 2604, Voluntary Specification for High Performance Organic Coatings on Architectural Extrusions & Panels.
   b. 1503, Voluntary Test Method for Thermal Transmittance and Condensation Resistance of Windows, Doors, and Glazed Wall Sections.
2. ASTM International (ASTM):
   a. C297/C297M, Standard Test Method for Flatwise Tensile Strength of Sandwich Constructions.
   b. D572, Standard Test Method for Rubber-Deterioration by Heat and Oxygen.
   c. D635, Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position.
   d. D1002, Standard Test Method for Apparent Shear Strength of Single-Lap-Joint Adhesively Bonded Metal Specimens by Tension Loading (Metal-to-Metal).
   e. D1037, Standard Test Methods for Evaluating Properties of Wood-Base Fiber and Particle Panel Materials.
   f. D2244, Standard Practice for Calculation of Color Tolerances and Color Differences from Instrumentally Measured Color Coordinates.
   g. D3163, Standard Test Method for Determining Strength of Adhesively Bonded Rigid Plastic Lap-Shear Joints in Shear by Tension Loading.
   h. D4060, Standard Test Method for Abrasion Resistance of Organic Coatings by the Taber Abraser.
   i. E72, Standard Test Methods of Conducting Strength Tests of Panels for Building Construction.
   j. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
   k. E283, Standard Test Method for Determining Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen.
   l. E699, Standard Practice for Evaluation of Agencies Involved in Testing, Quality Assurance, and Evaluating of Building Components.

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m. E1105, Standard Test Method for Field Determination of Water Penetration of Installed Exterior Windows, Skylights, Doors, and Curtain Walls by Uniform or Cyclic Static Air Pressure Difference.

3. International Code Council (ICC): AC 04, Acceptance Criteria for Sandwich Panels.
4. International Code Council – Evaluation Services (ICC-ES)
5. Military Specifications (MIL): DOD-P-15328D, Primer (Wash) Pretreatment (Formula #117 for Metals).
6. National Fenestration Rating Council (NFRC): 100, Procedure for Determining Fenestration Product U-Factors.
7. Underwriters Laboratories, Inc. (UL): UL 972, Standard for Burglary Resisting Glazing Material.

1.02 DESIGN REQUIREMENTS

A. Design translucent panel system to accommodate expansion and contraction within system components caused by a cycling temperature range of plus 100 degrees F to 0 degree F without causing detrimental effects to system or components.

B. Design and size members to withstand dead loads and live loads caused by snow, hail, and pressure and suction of wind acting perpendicular to panel system as calculated in accordance with applicable building codes and specified design criteria.

C. System shall accommodate, without damage to system or components or deterioration of perimeter seal(s):

1. Movement within system; movement between system and perimeter framing components; dynamic loading and release of loads; and deflection of structural support framing.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings: Plans, elevations including gridlines in each panel, sections, details, and attachment to other work.
2. Samples:
   a. Assembled panel at least 6 inches by 10 inches, with specified translucent facings and selected extrusion finishes. Include full size pieces showing joinery, anchorage, expansion provisions, and flashing.
   b. Aluminum extrusions finished with in color scheduled in the Drawings.

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B. Informational Submittals:

1. Manufacturer’s written approval of installer.
2. Maintenance Data: Cleaning and refinishing instructions and recommended products.

1.04 QUALITY ASSURANCE

A. Panel System Manufacturer: Listed by International Code Council as compliant with ICC AC04 Sandwich Panels. Current ICC-ES Evaluation Report for specific system shall affirm system can be installed in compliance with International Building Code.

B. Installer: Provide panel manufacturer’s letter of approval stating that the installer is approved for the installation of named manufacturer’s product(s).

1.05 DELIVERY, STORAGE, AND HANDLING

A. Store translucent panels on long edge, several inches above ground, blocked and under cover to prevent warping.

B. Ship units assembled and ready for erection.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Materials and products specified in this section shall be products of:

1. Kalwall Corp., Manchester, NH.
2. Major Industries, Wausau, WI.

2.02 MATERIALS

A. Translucent Fiberglass Face Sheets:

1. Strength: Exterior face sheet shall be uniform in strength and repel impact equal to 60 foot-pounds without fracture or tear.
2. Interior flamespread rating no greater than 50 and smoke developed no greater than 250, when tested in accordance with ASTM E84. Burn extent by ASTM D635 shall be no greater than 1 inch.
3. Exterior: Crystal, 0.070 inch thick.
4. Interior: White, 0.045 inch thick.
5. Free of ridges and wrinkles, which prevent proper surface contact in bonding to aluminum grid core. Clusters of air bubbles/pinholes that collect moisture and dirt will not be acceptable.

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6. Exterior Face:
    a. Shall not change color more than 3.0 units (DELTA-E by ASTM D2244) after 5 years' outdoor weathering South Florida at 5 degrees facing south, determined by average of at least three white samples.
    b. Shall have permanent glass veil erosion barrier and high performance thermoset acrylic protective surface (minimum thickness 1.2 mils) for maximum resistance to erosion and weather, applied in factory under controlled temperature conditions. Plastic overlay films are not acceptable. This coating shall be fully field refinishable if damaged.
7. Uniform in color.

B. Grid Core: Noncombustible aluminum I-beams, thermally broken at flat panels, 6063-T6, mechanical interlocking of muntin-mullion and perimeter, 7/16 inch width and thermally broken grid core shall have minimum Condensation Resistance Factor of 80 (AAMA 1503) measured on gridline.

C. Adhesive:

1. Heat and pressure resin type.
2. ICBO approved for use in sandwich panel construction.
3. Minimum Strength:
    a. Tensile:
        1) After two exposures to six cycles each of aging conditions in accordance with ASTM D1037:
            a) 750 psi by ASTM C297/C297M.
    b. Shear:
        1) After five separate aging conditions in accordance with ASTM D1002:
            a) 50 Percent Relative Humidity at 73 Degrees F: 540 psi.
            b) 182 Degrees F: 100 psi.
            c) Accelerated Aging by ASTM D1037 at Room Temperature: 800 psi.
            d) Accelerated Aging by ASTM D1037 at 182 Degrees F: 250 psi.
            e) 500-hour Oxygen Bomb by ASTM D572: 1,400 psi.

D. Battens and Perimeter Closure Systems:

1. Thermally Broken Battens and Closures: Extruded 6063-T6 and 6063-T5 aluminum screw clamp-tite closure system using 2-inch battens.
2. Fasteners: Stainless steel screws.

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E. Flexible Sealing Tape: Manufacturer's standard; preapplied to closure system at factory under controlled conditions.

F. Corrosion-Resistant Finish: Fluoropolymer fortified thermoset acrylic/urethane system that meets performance requirements of AAMA 2604.

1. Uniform in appearance.
2. Factory Applied Under Controlled Conditions:
   a. Aluminum wash-primed in accordance with MIL DOD-P-15328D.
   b. Even over entire exposed aluminum surface.
   c. Minimum Dry Thickness: 2 mils (0.002 inch).
3. Remain adhered to aluminum substrate with no blistering or peeling.
4. Color change shall be no greater than 3 DELTA-E Adams Units after 10 years' outdoor exposure at 5 degrees from vertical, facing south in South Florida.
5. Resistant to most chemicals including acids, alkalies, gases, salt solutions, and water.
6. Color as shown in Window and Relight Schedule.

2.03 FABRICATION

A. Translucent Wall Panels (TWP):

1. True structural composite flat sandwich panels of flat face sheets bonded to thermally broken grid core of mechanically interlocking aluminum I-beams. Laminate together under controlled process of heat and pressure. Tape bond systems are not allowed.
2. Uniform Thickness: 2-3/4 inches.
3. "U" Value: 0.29.
4. Light Transmission: 20 percent.
5. Shading Coefficient: 0.22.

B. Preassemble and seal panels at factory. Field assembly of major components will not be allowed.

C. Panel deflection for 10-foot clear span tested flat in accordance with ASTM E72 shall not exceed 1.9 inches at 30 pounds per square foot loading.

D. Grid Pattern: 12 inches by 12 inches nominal, and symmetrical about vertical centerline of each panel.

E. Adhesive Bonding Line: Straight, cover entire width of I-beam, and have a neat, sharp edge. In order to ensure bonding strength, white spots at intersections of muntins and mullions shall not exceed four for each 40 square feet of panel nor shall they be more than 3/64 inch wide.

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PART 3 EXECUTION

3.01 PREPARATION

A. Prepare openings, including isolating aluminum system, from dissimilar materials that may cause damage by electrolysis.

3.02 ERECTION

A. Erect insulated translucent panel systems in strict accordance with manufacturer's instructions. Fasten and seal in strict accordance with manufacturer's shop drawings. Clean aluminum before applying sealants.

B. After other trades have completed work on adjacent material, carefully inspect translucent panel unit installation, ensure no shifting or rattling, and make adjustments necessary to ensure proper installation and weathertight conditions.

3.03 CLEANING

A. Leave translucent panels in undamaged condition and ready for final cleaning.

B. Clean both faces of panels in accordance with manufacturer's instructions.

3.04 PROTECTION OF COMPLETED WORK

A. Install marker tape across panels secured to frames or structure. No tape or marking allowed on panels after final cleaning.

END OF SECTION

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SECTION 08 71 00
DOOR HARDWARE

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Builders Hardware Manufacturer's Association (BHMA):
   a. A156.1, Butts and Hinges.
   b. A156.2, Bored and Preassembled Locks and Latches.
   c. A156.3, Exit Devices.
   d. A156.4, Door Controls - Closers.
   e. A156.13, Mortise Locks & Latches.
   f. A156.16, Auxiliary Hardware.
   g. A156.18, Materials and Finishes.
2. International Code Council (ICC): A117.1, Accessible and Usable Buildings and Facilities.
3. Underwriters Laboratories, Inc. (UL): Fire Protection Equipment List.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Product Data: Manufacturer's literature for each item of finish hardware required herein, clearly marked.
   b. Finish Hardware Schedule: Furnish complete and detailed schedule, show product items, numbers, and finishes for hardware for each separate opening.
   c. Special Tools: Provide listing and description of usage.
2. Samples:
   a. **[A: .]**
   b. **[B: .]**

B. Informational Submittals:

1. Operation and Maintenance Data as specified in Section 01 78 23, Operation and Maintenance Data.
2. Manufacturer's Field Service Report.
3. Certification of Hardware Consultant.
4. Manufacturer's Certificate of Compliance, in accordance with Section **[A: 01 61 00, Common Product Requirements] [B:]**.

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1.03 QUALITY ASSURANCE

A. Qualifications of Supplier: Recognized supplier of architectural finish hardware, with warehousing facilities, who has been furnishing hardware in vicinity of Project for not less than 5 years, and who is, or who employs, architectural hardware consultant.

B. Qualifications of Architectural Hardware Consultant (AHC): Certified by Door and Hardware Institute.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Before delivery, clearly identify and tag each item of hardware with respect to specified description and location of installation.

B. Provide secure storage for finish hardware until installation is made.

1.05 EXTRA MATERIALS

A. Special Tools: Two sets for installation and maintenance of hardware.

PART 2 PRODUCTS

2.01 MATERIALS

A. Provide end products of one manufacturer for each product in order to achieve standardization for appearance, maintenance, and replacement.

B. Finishes: BHMA A156.18.

C. **[A: Some products listed below may not be used on this Project.]**

2.02 FASTENERS

A. Stainless steel.

2.03 BUTT HINGES

A. BHMA A156.1.

B. Quantity per Door Leaf (Minimum):

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Door Height	Hinges
Up to 5'-0"	1 pair
5'-1" to 7'-7"	1-1/2 pair
7'-8" to 10'-0"	2 pairs
10'-1" to 12'-6"	2-1/2 pairs

C. Hinge Height (Minimum):

Door Width	Hinge Height
Up to 3'-0"	4-1/2"
3'-1" to 4'-0"	5"
Over 4'-0"	6"

D. Width: Minimum for clearance of trim and 180-degree swing.

E. Exterior Hinges: Nonremoveable pin.

F. Joint Tolerance: 0.012 inch maximum, gauged in CLOSED position.

G. Finish: **[A: Satin stainless steel No. 630.] [B: Satin bronze No. 612.] [C: Satin chromium-plated brass or bronze No. 626.] [D: Satin chromium-plated steel No. 652.] [E: Primed for paint No. 600.] [F: As indicated for each type.]**

H. Types and Manufacturers:

No.	Type Description	Stanley	Mc-Kinney	Lawrence	BHMA
H1	Regular weight, two ball-races, full mortise, **[A: brass, bronze] [F: steel] [K: stainless steel]**	**[B: FBB191] [G: FBB179] [L: FBB191-32D]**	**[C: TB2314] [H: TB2714] [M: TB2314]**	**[D: BB4101-1] [I: BB4101] [N: BB4101-32D]**	**[E: A2112] [J: A8112] [O: A5112]**
H2	Plain bearing, full mortise, **[P: brass or bronze] [U: steel] [Z: stainless steel]**	**[Q: F191-32D] [V: F191] [AA: F179]**	**[R: T2314] [W: T2314] [AB: T2714]**	**[S: 4181-32D] [X: 4181-1] [AC: 4181]**	**[T: A2133] [Y: A8133] [AD: A5133]**
H3	Hinges or pivots furnished by door manufacturer				
H4	Extra heavy-weight, four ball races, full mortise, stainless steel	FBB199-32D	T4B3386	BB5151-A	A5111
H5	Heavyweight, four ball races, half mortise, stainless steel	FBB98	T4B3384	BB5651-32D	A5211

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No.	Type Description	Stanley	Mc-Kinney	Lawrence	BHMA
H6	Heavyweight, four ball races, half mortise, stainless steel	FBB113	T4B3382	BB9351-32D	A5411

2.04 LOCKS AND LATCH SETS

A. Cylindrical or Bored Locks: BHMA A156.2, highest grade.

1. Trim: Wrought or cold-forged metal knobs and roses.
2. Core Cylinders: Interchangeable, removable; minimum of six pins.
3. Strikes: Lip dimensions to fit configuration of trim.
4. Bolt Throw: 3/4 inch minimum, on latchbolts for pair of doors.
5. Knob Backset: **[A: 3-3/4] [B: 2-3/4]** inches.
6. Manufacturers and Products:
   a. Sargent; AC.
   b. Schlage; Plymouth.
   c. Best; 4C Washington.

B. Mortise Locks: BHMA A156.13, Series 1000, Grade 1.

1. Materials: Brass or stainless steel.
2. Trim: Wrought or forged lever handles and roses.
3. Core Cylinders: Interchangeable, removable; minimum of six pins.
4. Bolt Throw: 5/8 inch minimum.
5. Lever Backset: 2-3/4 inches.
6. Manufacturers and Products:
   a. Sargent; LNJ.
   b. Schlage; 03.
   c. **[A: Best; 3H Fairbanks.]**

C. Tactile Warning: Knurl knob backs and lever handles for touch identification; ICC A117.1, Section 4.29.3.

D. Finish:

1. **[A: Satin stainless steel No. 630.] [B: Satin chromium-plated No. 626.]**
2. **[C: Coat exterior [D: knobs] [E: and] [F: levers] with Teflon.]**

E. **[A: Locks and Latches: Match existing in manufacturer, design, finish, and keying. No substitutions allowed.]**

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F. Types and Manufacturers:

No.	Type Description	Best	Sargent	Schlage	BHMA
L1	Mortise entrance lock with lever handle	45H7TA3H	8245-LNJ	L9456P-03	F12, F13
L2	Bored, entrance lock	84K7AB4C	9G05	C53PD	F81, F82
L3	Mortise latch with lever handle	45H0N3H	8215-LNJ	L9010-03	F01
L4	Bored latch	84K0N4C	9U15	C10S	F75
L5	Mortise utility room lock with lever handle	45H7D3H	8204-LNJ	L9080-03	F07
L6	Bored, utility room lock	84K7D4C	9G04	C80PD	F86
L7	Deadlock	83T7K	15-475	B560	E2151
L8	Mortise privacy lock with lever handle	45H7L3H	8265-LNJ	L9040-03	F19, F22
L9	Bored, privacy lock	84K0L4C	9U65	C40S	F76
L10	Cabinet lock, drawer and door	3L7RD	1654	46-002	E07121
L11	Lock by door manufacturer; furnish cylinders for keying to other locks as required				
L12	Bored, exit only, lock	84K0Y4C	9G13	C12D	F89
L13	Padlock	61BRT	756HS	45-101	
L14	Fixed knob pull and roller; Latch: Ives 336, Stanley C44S	84K1DT4C	9U93	D170	
L15	Push-pull latch		115	Corbin 1860	
L16	Lock by exit device manufacturer; furnish cylinders for keying to other locks as required				

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G. Keying:

1. Lock Cylinders: Operate by **[A: grand]** master key system that allows for future expansion.
2. Keylocks: **[B: As indicated in Door and Hardware Schedule.] [C: Key new locks into existing [D: Best] master key system.] [E: As directed by Owner.]**
3. Keys: Two per lock; tag with schedule information.
4. Master Keys: Four; send by registered mail to **[F: Engineer] [G: Owner]**.
5. **[H: Key cabinet and casework locks into building system.]**
6. **[I: Furnish lock manufacturer's removable core maximum security keying system.]**

2.05 CONSTRUCTION KEY SYSTEM

A. Removable construction core system for locks.

B. See Article Manufacturer's Services under Part 3, Execution.

2.06 CONSTRUCTION KEY SYSTEM

A. Assemble permanent cylinders with construction inserts and ship with all lock sets.

B. Change Keys: Pack in separately identified envelopes and ship.

C. Construction Keys: Pack in cartons marked "packing list" and ship.

D. Construction Insert Extractor Keys, Master Keys, and Grand Master Keys: Ship by registered mail to **[A: Engineer] [B: Owner]**.

E. On completion of job, deliver construction keys to Owner.

2.07 EXIT DEVICES

A. BHMA A156.3.

B. Furnish fire exit devices and mullions at fire-rated doors.

C. **[A: Key Lockable,]** Removable Mullion: **[B: Steel] [C: Aluminum]** construction, by exit device manufacturer.

D. Trim:

1. Knobs: Sargent PRK; Von Duprin K.
2. Levers: Sargent ETJ; Von Duprin 03.

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E. Finish:

1. Exit Device: Satin chromium-plated No. 626.
2. Removable Mullion: **[A: Steel with prime coat.] [B: Aluminum with prime coat.] [C: Mill aluminum.]**

F. Types and Manufacturers:

No.	Type Description	Sargent	VonDuprin	BHMA
X1	Rim type, active leaf; with removable mullion for pairs	**[A: 8813PRK] [C: 8813ETJ]**	**[B: 99K] [D: 99L]**	Type 1 08
X2	Rim type, exit only	8810	99EO	Type 1 01
X3	Vertical rod type	**[E: 8713PRK] [G: 8713ETJ]**	**[F: 9927K] [H: 9927L]**	Type 2 08
X4	Vertical rod type for pairs	**[I: 8713PRK and 8710] [K: 8713ETJ and 8710]**	**[J: 9927K and 9927EO] [L: 9927L and 9927EO]**	Type 2 08 and 01
X5	Vertical rod type, exit only, for singles or pairs	8710	9927EO	Type 2 01
X6	Concealed vertical rod type	**[M: 8613PRK] [O: 8613ETJ]**	**[N: 9947K] [P: 9947L]**	Type 8 08
X7	Concealed vertical rod type for pairs	**[Q: 8613PRK and 8610] [S: 8613ETJ and 8610]**	**[R: 9947K and 9947EO] [T: 9947L and 9947EO]**	Type 8 08 and 01
X8	Concealed vertical rod type, exit only, for singles and pairs	8610	9947EO	Type 8 01
X9	Exit device by door manufacturers			
X10	Rim type, active leaf, latch function; with removable mullion for pairs	**[U: 8815PRK] [W: 8815ETJ]**	**[V: 99K-BE] [X: 99L-BE]**	Type 1
X11	Vertical rod type, latch function	**[Y: 8715PRK] [A: 8715ETJ]**	**[Z: 9927K-BE] [B: 9927L-BE]**	Type 2
X12	Vertical rod type for pairs, latch function	**[C: 8715PRK and 8710] [E: 8715ETJ and 8710]**	**[D: 9927K-BE and 9927EO] [F: 9927L-BE and 9927EO]**	Type 2

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No.	Type Description	Sargent	VonDuprin	BHMA
X13	Concealed vertical rod type, latch function	**[G: 8615PRK] [I: 8615ETJ]**	**[H: 9947K-BE] [J: 9947L-BE]**	Type 8
X14	Concealed vertical rod type for pairs, latch function	**[K: 8615PRK and 8610] [M: 8615ETJ and 8610]**	**[L: 9947K-BE and 9947EO] [N: 9947L-BE and 9947EO]**	Type 8

2.08 CLOSERS

A. BHMA A156.4.

B. Size closers in accordance with manufacturer's standards. Mount regular arm closers on pull side of doors. Mount parallel arm closers on push side of doors. On pair of doors provide closer on active leaf only, unless noted otherwise.

C. Finish: **[A: Satin chromium-plated No. 626.] [B:] [C: Manufacturer's standard painted or powder coated finish] [D: , with special rust inhibiting (SRI) pretreatment] [E: , in color selected by Engineer from manufacturer's standard color range]**.

D. Types and Manufacturers:

No.	Type/Description	LCN	Sargent	BHMA
C1	Regular arm	4010 Series	351 Series	C02011
C2	Parallel arm	4110 Series	351-P Series	C02021
C3	Regular arm with hold-open	4010H Series	351-H Series	C02051
C4	Parallel arm with integral stop	4110 Cush-N-Stop Series	351-PS Series	C02021
C5	Parallel arm with hold-open	4110H Series	351-PH Series	C02061
C6	Parallel arm with integral stop and hold-open	4110H Cush-N-Stop Series	351-PSH Series	C02061
C7	Closer furnished by door and frame manufacturer			

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2.09 PUSH-PULLS

A. Solid metal, not plated.

B. Finish: **[A: Satin stainless steel No. 630,] [B: Satin chromium-plated No. 626,] [C: Satin bronze No. 612,]** unless indicated otherwise.

C. Plates: Beveled four edges, square corners.

D. Pulls: Bolted through door.

E. Push Plates: Countersink pull-through bolts and cover with push plate.

F. Types and Manufacturers:

No.	Type Description	BBW	Baldwin
P1	8" x 3/4" Pull handle on plate: 0.050" x 4" x 16", and push plate: 0.050" x 8" x 16"	1017-3B and 47-G	2367 and 2125
P2	Push bar and pull handle: Furnished by door manufacturer		
P3	8" x 3/4" Pull handles: Both sides	2903	2552

2.10 STOPS AND HOLDERS

A. BHMA A156.16.

B. Machine Screws: In threaded anchors at concrete or masonry.

C. Self-Tapping Screws: At stud partitions, wood, or metal mountings.

D. Metal Risers: For mounting at carpet floors.

E. Finish: Satin chromium-plated No. 626.

F. Types and Manufacturers for Each Leaf:

No.	Type Description	BBW or GJ	Baldwin	BHMA
S1	Floor stop	F121X	4086	L02131
S2	Wall bumper	**[A: WC9X] [D: WC9T]**	**[B: 4031] [E: 4032]**	**[C: L02241] [F: L02251]**
S3	Wall stop-holder	**[G: W140] [J: W141X]**	**[H: 4090] [K: 4091]**	**[I: L02251] [L: L01351]**

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No.	Type Description	BBW or GJ	Baldwin	BHMA
S4	Floor stop-holder	F823X	4096	L01371
S5	Door-attached holder	872	4105	L01381
S6	Overhead stop	GJ90S Series	Sargent 590S Series	C02511
S7	Overhead stop with hold-open	GJ90H Series	Sargent 590H Series	C05541
S8	Heavy-duty overhead stop	GJ79HDS		
S9	Spring and chain stop	Ives 115	4485	
S10	Stop or holder furnished by door manufacturer			

2.11 BOLTS

A. BHMA A156.16.

B. Finish: Bright nickel No. 645.

C. Types and Manufacturers:

No.	Type/Description	Stanley	Lawrence	BHMA
B1	Top and bottom flush bolts	393-1/2	280	L04201
B2	Top and bottom surface bolts	CD4060	283	(L04151)
B3	Top: 8" bolt w/48" chain	1055	T146	
	Bottom: 8" foot-bolt or surface bolt	1056 4060	T145 283	
B4	Surface bolt, 4"	4060	283	
B5	Cane bolt, 18"	1010	T250	
B6	Automatic flush bolts	**GJ** **[A: FB7]** **[B: FB8]**	**Ives** **[C: 559]** **[D: 556]**	

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2.12 KICKPLATES

A. **[A: Solid metal, not plated.] [B: Plastic laminate.]** Bevel four edges.

B. Width of door leaf less than 1-1/2 inches at single leaf and less than 1 inch at pairs.

C. Finish: **[A: Satin stainless steel No. 630.] [B: Color as scheduled.] [C: Color: _____.]**

D. Types and Manufacturers: Builders Brass Works, Baldwin, Rockwood, or Cipco as follows:

1. K1 10 inches high by **[A: 0.05] [B: 0.125]** inch thick.
2. K2 36 inches high by **[C: 0.05] [D: 0.125]** inch thick.

2.13 THRESHOLDS

A. Thresholds: One-piece full width of opening; extend beyond jamb where indicated.

B. Provide with stainless steel machine screws in threaded expansion anchors at concrete.

C. Finish: **[A: Mill finish] [B: Dark bronze anodized]** aluminum, unless indicated otherwise.

D. Types and Manufacturers:

No.	Type Description	Pemko	Reese
T1	Saddle (smooth, 4" x 1/2")	**[A: 175A] [C: 175D]**	**[B: S104A] [D: S104D]**
T2	Saddle (serrated, 4" x 1/4")	**[E: 270A] [G: 270D]**	**[F: S404A] [H: S404D]**
T3	Threshold furnished by door manufacturer		
T4	Thermal break saddle (6-1/8")	**[I: 253XAFG] [K: 253XDFG]**	**[J: S473A] [L: S473D]**
T5	Carpet edge	**[M: 174C] [O: 174D]**	**[N: 266A] [P: 266D]**
T6	Panic exit saddle	**[Q: 2005AV] [S: 2005DV]**	**[R: S483AV] [T: S483DV]**

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2.14 WEATHERSTRIP

A. Finish: **[A: Clear] [B: Dark bronze]** anodized aluminum, unless indicated otherwise.

B. Seal Types and Manufacturers:

No.	Type Description	Pemko	Reese
W1	Rubber or vinyl bulb at jambs and head, and at meeting stiles of pairs	S88D	797B
	Door shoe	**[A: 222AV] [C: 222DV]**	**[B: DB596AF] [D: DB596DF]**
	Rain drip	**[E: 346C] [G: 346D]**	**[F: R201C] [H: R201D]**
W2	Rubber or vinyl bulb at jambs and head, and at meeting stiles of pairs	S88D	797B
	Door shoe	**[I: 222AV] [K: 222DV]**	**[J: DB596AF] [L: DB596DF]**
W3	Rubber vinyl bulb at jambs and head, and at meeting stiles of pairs	S88D	797B
	Door bottom with drip	**[M: 345AV] [O: 345DV]**	**[N: 353A] [P: 353D]**
	Interlocking watershed	**[Q: 68 AR & 347A] [S: 68DR & 347D]**	**[R: 202C & 203C] [T: 202D & 203D]**
W4	Flexible plastic at jambs, head, and at meeting stiles of pairs	PF114PS	794B
W5	Weatherstripping furnished by door manufacturer		
W6	Rubber or vinyl bulb at jambs and head, and at meeting stiles of pairs	S88D	797B
	Automatic door bottom	**[U: 412CRL] [W: 412DRL]**	**[V: 320C] [X: 320D]**

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2.15 MISCELLANEOUS ITEMS

A. Provide as indicated in Door and Hardware Schedule:

M1	Nameplate as specified in Section 10 14 00, Signage, in text noted in Door and Hardware Schedule		
M2	Nameplate and barrier-free pictorial symbol as specified in Section 10 14 00, Signage, in text noted in Door and Hardware Schedule		
M3	Barrier-free pictorial symbol, 6 inch by 6 inch, as specified in Section 10 14 00, Signage, in text noted in Door and Hardware Schedule		
M4	Bypassing Door Hardware:		
		Lawrence	**Stanley**
	Set	EDF500 Series, with integral fascia	Series 1700, with integral fascia
	Brass pulls	405	303-STL3
M5	Pocket Door Hardware:		
		Lawrence	**Stanley**
	Set	PF619	Series 40-3940
	Brass pulls	411	100-B
M6	Bifold Door Hardware:		
		Lawrence	**Stanley**
	Set	ED600	Series 2700
	Brass pulls	Quality 813	4484
M7	Coordinator:		
		GJ	**Ives**
	Model	COR-65	469

2.16 SILENCERS

A. Ives, Glynn-Johnson.

B. At metal frame of each hinged door that does not have seals scheduled.

C. Three at single leaves and two at pairs.

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2.17 NAMEPLATES

A. Material: Plastic plate; 1/8 inch thick with beveled edges.

B. Types and Manufacturers: Builders Brass Works, Trimco, and as follows:

N1	2"-high black plate with 1"-high white Helvetica medium letters in text noted in Door and Hardware Schedule
N2	Same as N1 with addition of barrier-free pictorial symbol

2.18 TEMPLATES

A. Fabricate to template hardware applied to metal doors and frames.

B. Ensure that required templates are furnished to various manufacturers for fabrication purposes.

C. Templates: Make available not more than 10 days after receipt of approved Hardware Schedule.

2.19 EXIT AND FIRE DOORS

A. Exit Doors: Always openable from inside by simple turn of **[A: knob] [B: lever handle]** or push on panic bar without use of key or any special knowledge or effort, to include each leaf of door pairs.

B. Hardware for Fire Doors: Underwriters Laboratories Inc., Fire Protection Equipment List.

2.20 KEY CONTROL SYSTEM

A. System: Key Control Systems Co., Telkee, Inc., expandable system with **[A: 150 (E8351)] [B: 25 (E8331)]**-key capacity expandable to **[C: 425] [D: 125]**.

B. Cabinet:

1. Manufacturer’s standard surface mounted cabinet, single-door with continuous hinge, and pin tumbler lock, color as selected from standard colors to match Engineer’s color schedule. **[A: Use Telkee AWC 150-S] [B: Use Telkee RWC-P 25-S]**.
2. Complete system with standard components such as envelopes, transient key tags, reserve key tags, receipts and holders, and card index.

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PART 3 EXECUTION

3.01 INSTALLATION

A. In accordance with manufacturer's written instructions.

B. Make Work neat and secure, develop full strength of components, and provide proper function.

C. Prevent marring, scratching, or otherwise damaging adjacent finishes during hardware installation.

D. Latchbolts:

1. Install to engage in strikes automatically, whether activated by closers or manually.
2. In no case shall additional manual pressure be required to engage latchbolt in strike.

E. Stops and Holders: Set to allow doors to open as far as possible.

F. Wall Mounted Hardware: Install over solid structural backing or solid blocking in hollow walls.

G. Thresholds:

1. Cope ends neatly to profile of jamb.
2. Set in sealant and seal ends to jambs.

H. Key Control System Cabinet: Install where shown.

I. Hardware: Adjust for easy, noise-free operation.

J. Replace damaged hardware items.

3.02 MOUNTING DIMENSIONS

A. Standard Door Hardware Locations: As recommended and published by Door and Hardware Institute, except as noted or detailed otherwise.

B. Door Silencers: Install 3 inches from top and bottom of jamb and 1 inch above strike at single doors, and 3 inches from edges of doors in head for pairs of doors.

C. Nameplates: Attach to doors **[A: or walls adjacent to doors]** 5 feet 6 inches above floor using **[B: Phillips head screws] [C: self-sticking [D: permanent] [E: removable] adhesive]**.

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3.03 MANUFACTURER'S SERVICES

A. Deliver permanent lock cores to Site.

B. Remove temporary construction cores and insert permanent cores.

C. Inspect each lock set to ensure permanent cores are operating satisfactorily.

D. Deliver to Owner change and control keys for permanent system.

E. Return temporary construction cores to manufacturer.

F. Furnish manufacturer's representative for the following services at Site or classroom as designated by **[A: Owner,] [B: ,]** for minimum person-days listed below, travel time excluded:

1. **[C:]** person-days for installation assistance, inspection, and Manufacturer's Certificate of Proper Installation.
2. **[D:]** person-days for **[E: functional] [F: and] [G: performance]** testing.

3.04 PROTECTION

A. Cover and protect exposed surfaces of hardware during installation and until Substantial Completion.

B. Fit, dismantle, and reinstall finish hardware as required for finish painting work.

C. Protect and prevent staining of hardware during construction in accordance with manufacturer's recommendations.

D. Remove protective measures and permanent lock cylinders installed prior to final cleaning.

3.05 DOOR AND HARDWARE SCHEDULE

A. Door and Hardware Schedule **[A: on Drawings] [B: in Section 08 06 01, Door and Hardware Schedule,]** is guide to functional requirements of each opening.

B. Provide finish hardware as scheduled. Sizes omitted shall be as recommended by manufacturer.

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3.06 HARDWARE SETS

HDW-1:	Item	Type
	3 Pair butts	H1
	2 Exit devices (rim type) with cylinders for keying to other locks as required	X1
	1 Removable mullion	X1
	2 Closers	C2
	2 Floor stops and holders	S4
	2 Metal kickplates	K1
	1 Threshold	T1
	1 Set weatherstrip	W1
HDW-2:	**Item**	**Type**
	1-1/2 Pair butts	H1
	1 Lock	L2
	1 Closer	C2
	1 Floor stop	S1
	1 Metal kickplate	K1
	1 Threshold	T1
	1 Set weatherstrip (narrow stop)	W2
HDW-3:	**Item**	**Type**
	1-1/2 Pair butts	H1
	1 Lock	L1
	1 Closer	C2
	1 Floor stop and holder	S4
	1 Threshold	T1
	1 Set weatherstrip	W2

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HDW-4:	Item	Type
	1-1/2 Pair butts	H1
	1 Latch	L4
	1 Closer	C1
	1 Wall bumper	S2
	1 Plastic kickplate	K1
	1 Nameplate	M2
HDW-5:	**Item**	**Type**
	1-1/2 Pair butts	H1
	1 Privacy lock	L9
	1 Closer	C1
	1 Wall bumper	S2
	1 Nameplate	N1
HDW-6:	**Item**	**Type**
	1-1/2 Pair butts	H2
	1 Latch	L4
	1 Floor stop	S1
HDW-7:	**Item**	**Type**
	1-1/2 Pair butts	H2
	1 Lock	L2
	1 Floor stop	S1
HDW-8:	**Item**	**Type**
	3 Pair butts	H1
	1 Lock	L2
	2 Floor stop and holders	S4
	2 Flush bolts	B1

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HDW-9:	Item	Type
	4 Pair butts, stainless steel	H4
	1 Lock	L2
	2 Wall stop and holders	S3
	1 - 8" Chain and foot-bolts	B3
	1 Threshold	T1
	1 Set weatherstrip	W1
HDW-10:	All hardware by door manufacturer except cylinder	

END OF SECTION

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SECTION 08 80 00
GLAZING

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American National Standards Institute (ANSI): Z97.1, Safety Glazing Materials Used in Buildings—Safety Performance Specifications and Methods of Test.
2. American Society of Civil Engineers (ASCE): 7, Minimum Design Loads for Buildings and Other Structures.
3. ASTM International (ASTM):
    a. C864, Standard Specification for Dense Elastomeric Compression Seal Gaskets, Setting Blocks, and Spacers.
    b. C1036, Standard Specification for Flat Glass.
    c. C1048, Standard Specification for Heat-Treated Flat Glass—Kind HS, Kind FT Coated and Uncoated Glass.
    d. D635, Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position.
    e. D2843, Standard Test Method for Density of Smoke from the Burning or Decomposition of Plastics.
    f. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
    g. E119, Standard Test Methods for Fire Tests of Building Construction and Materials.
4. Consumer Product Safety Commission (CPSC) Code of Federal Regulations (CFR): 16 CFR 1201, Safety Standard for Architectural Glazing Materials.
5. Glass Association of North America (GANA):
    a. Glazing Manual.
    b. Sealant Manual.
6. National Fire Protection Association (NFPA):
    a. 80, Safety Standard for Fire Doors and Other Opening Protectives.
    b. 252, Safety Standard Methods of Fire Tests of Door Assemblies.
    c. 257, Safety Standard on Fire Test for Window and Glass Block Assemblies.
7. Underwriters Laboratories Inc. (UL):
    a. Building Materials Directory.
    b. 10C, Standard for Safety for Positive Pressure Fire Tests of Door Assemblies.

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1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Complete schedule of glass and glazing material to be used for each purpose.
   b. Indicate sizes, layout, thicknesses, and loading conditions for glass.
2. Product Data:
   a. Catalog cuts of glazing materials with inclusion of glass edge cutting procedures.
   b. Glass: Provide structural, physical, and thermal and solar optical performance characteristics, size limitations, special handling or installation requirements.
3. Samples:
   a. Glass: Two samples 3-inch by 4-inch in size, illustrating each glass type scheduled on the Drawings.

B. Informational Submittals: Manufacturer's Certificate of Compliance for each type of glazing shown in the architectural schedule in the Drawings.

1.03 DELIVERY, STORAGE, AND HANDLING

A. Storage:

1. Support cases on both sides when stored vertically.
2. After unpacking, place interleaving protection between lites.
3. Keep glass and interleaving dry by storing inside where temperatures are above dewpoint, or if outside storage is necessary, cover glass interleaving with opaque tarpaulins or plastic and inspect periodically. Wet interleaving can stain glass.
4. Avoid exposing stored glass to direct sunlight.

B. Handling:

1. Stack individual lites on edge and lean them against sturdy uprights at a slope of 5 degrees to 7 degrees from vertical.
2. Cushion bottom edges with soft, firm pads free of dirt, grit, glass chips, or other foreign material.
3. Do not rotate or cartwheel insulating glass units over their corners. Use turning device such as a rolling block if units must be rotated.

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PART 2 PRODUCTS

2.01 GENERAL

A. Single Source Fabrication Responsibility: Fabrication processes, including Low-E and reflective coatings, insulating, laminating, silkscreen, and tempering, shall be fabricated by a single fabricator.

B. Performance/Design Criteria:

C. Wind Loads: Design and size glass to withstand positive and negative wind loads acting normal to plane of wall, including increased loads at building corners.

1. Design Wind Load: As calculated in accordance with applicable code and ASCE 7 with 90 mph basic wind speed, exposure C.

2.02 FLOAT GLASS MATERIALS

A. Annealed Glass:

1. ASTM C1036, Type 1 transparent flat, Quality Q3, float glass.
2. Furnish annealed glass except where heat strengthened or tempered glass is required to meet specified performance requirements.

B. Tempered Glass (SG):

1. ASTM C1048, Type 1 transparent flat, Quality Q3, Kind FT fully tempered, Condition A uncoated, float glass with horizontal tempering.
2. Furnish tempered glass where heat strengthened glass cannot meet specified performance requirements.
3. Conforming to CPSC 16 CFR 1201 at locations where safety glass is required by applicable code.

2.03 FLOAT GLASS PRODUCTS

A. Clear Float Glass:

1. Annealed or Tempered float glass as specified; Class 1 clear.
2. Minimum Thickness: 1/4 inch.

2.04 INSULATING GLASS PRODUCTS

A. Insulating Glass (IG):

1. ASTM E2190.
2. Total Unit Thickness: 1-inch.

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3. Insulating Glass Unit Edge Seal Construction: Aluminum, bent and soldered corners.
4. Outer Pane: Glass Type: Clear Float Glass as specified.
5. Inner Pane: Glass Type: Clear Float Glass as specified.
6. Low-e Coating: Surface 2.
7. U-Factor: 0.25 maximum.
8. Solar Heat Gain Coefficient: 0.40 maximum.
9. Visible Light Transmittance: 72 percent minimum.
10. Manufacturer and Product:
    a. PPG; Solrban 60 Insulating Glass, Low-e, Clear.
    b. Or approved equal.

B. Soft Gaskets:

1. ASTM C509 Type II; resilient extruded shape to suit glazing channel retaining slot; black color.
2. Neoprene.
3. EPDM.
4. Silicone.

C. Preformed Glazing Tape:

1. Size to suit application.
2. Preformed butyl compound; 10 to 15 Shore A durometer hardness; coiled on release paper; black color.
3. Butyl Corner Sealant: ASTM C920 single component non-skinning butyl compatible with glazing tape; color to match tape.

2.05 GLAZING ACCESSORIES

A. Setting Blocks: Elastomeric material recommended by glass manufacturer, 80 to 90 Shore A durometer hardness, length of 0.1 inch for each square foot (25 mm for each square meter) of glazing or minimum 4 inch (100 mm) by width of glazing rabbet space minus 1/16 inch (1.5 mm) by height to suit glazing method and pane weight and area.

B. Spacer Shims: Elastomeric material recommended by glass manufacturer, 50 to 60 Shore A durometer hardness, minimum 3-inch (75-mm) long by one half the height of glazing stop by thickness to suit application self adhesive on one face.

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PART 3 EXECUTION

3.01 EXAMINATION

A. Verify openings for glazing are correctly sized and within acceptable tolerance.

B. Verify surfaces of glazing channels or recesses are clean, free of obstructions impeding moisture movement, weeps are clear and ready to receive glazing.

3.02 PREPARATION

A. Do not perform glazing work in damp, foggy, or rainy weather, or when temperatures are not within range recommended by GANA “Glazing Manual”.

B. Surfaces:

1. Smooth, even, sound, dry, and clean.
2. Clean contact surfaces with solvent and wipe dry.

C. Priming:

1. Complete and cured.
2. Prime surfaces scheduled to receive sealant.

D. Measure size of frames to receive glass and compute actual glass size allowing for edge clearances.

E. Verify functioning weep system is present.

F. Do not proceed with glazing until unsatisfactory conditions have been corrected.

3.03 GLAZING INSTALLATION

A. Interior Dry Method (Tape and Tape) Installation:

1. Cut glazing tape to length and set against permanent stops, projecting 1/16 inch (1.6 mm) above sight line.
2. Place setting blocks at 1/4 points with edge block no more than 6 inches (150 mm) from corners.
3. Rest glazing on setting blocks and push against tape for full contact at perimeter of pane or unit.
4. Place glazing tape on free perimeter of glazing in same manner described above.

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5. Install removable stop without displacement of tape. Exert pressure on tape for full continuous contact.
6. Knife trim protruding tape.

3.04 FIELD QUALITY CONTROL

A. Hose Test:

1. Use 3/4-inch minimum hose without nozzle. With full stream, flood glazing from bottom to top.
2. Correct leaks disclosed by hose test by reglazing and retesting until eliminated.

3.05 MANUFACTURER'S FIELD SERVICES

A. Provide manufacturer's representative at Site in accordance with Section 01 43 33, Manufacturers' Field Services, for installation assistance and inspection.

3.06 CLEANING

A. Leave glass and glazing in undamaged condition and ready for final cleaning.

B. Remove excess glazing compound from installed glass.

C. Remove labels from glass surface at time of final cleaning.

D. Wash and polish both faces of glass.

E. Clean adjacent surfaces of glass.

3.07 PROTECTION OF COMPLETED WORK

A. Protection:

1. Keep glass free from contamination by materials capable of staining glass.
2. Install tape across lights secured to frames or structure.
3. No tape or marking allowed on glass.

B. Replacements and Repairs: Prior to Substantial Completion, replace broken, defective, or scratched glass and repair damaged compounds.

END OF SECTION

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SECTION 08 90 00
LOUVERS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Air Movement and Control Association (AMCA): 500-L, Laboratory Methods of Testing Louvers for Rating.
2. The Aluminum Association, Incorporated (AA): Designation System for Aluminum Finishes.
3. Underwriters Laboratories, Inc. (UL): Building Materials Directory.

1.02 DESIGN REQUIREMENTS

A. Installed Louvers: Capable of resisting wind load of 30 pounds per square foot.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings: Large scale details of louvers, anchorage, and relationship to adjoining construction.
   a. Manufacturer's Literature:
      1) Descriptive and performance data of louvers, including standard drawings and louver-free area.
2. Samples: Three each, 2 inches by 3 inches, representative of louver material, finish specified, and color scheduled on the Drawings.

PART 2 PRODUCTS

2.01 GENERAL

A. Nonacoustical louver sizes are based on 50 percent free area and 800 fpm maximum velocity through free area. Water Penetration Rate: No greater than 0.02 ounce per square foot.

B. Louvers: Rated and tested in accordance with AMCA 500-L.

2.02 FIXED STORMPROOF LOUVERS (TYPE SP)

A. Frame: Extruded aluminum channel, 0.081 inch thick, 4 inches deep, with concealed mullions.

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B. Blades: Extruded aluminum, 0.081 inch thick, Z-shaped, 35-degree to 45-degree pitch angle, spaced 3 inches to 4.25 inches on center.

C. Pressure Loss: AMCA certified rating of no greater than 0.10-inch WC.

D. Sizes: As scheduled and shown on Drawings.

E. Screen: Inside mounted, painted aluminum, 1/8-inch mesh.

F. Finish: Kynar 500 fluorocarbon coating in color as scheduled on the Drawings.

G. Manufacturers and Products:

1. Construction Specialties; Model 4110.
2. Dowco; Series LEB-4.
3. Ruskin; Model ELF-375DXH.

2.03 ACCESSORIES

A. Anchors and Fasteners: Stainless steel.

B. Flashings: Match louver frame.

C. Isolation Tape: Tremco 440, 3M EC1202, or Presstite 579.6.

D. Isolation Paint: ASTM D1187, bituminous coating.

E. Insulated Blank-Off Panels:

1. Panels: Urethane core faced on both sides with 0.032-inch stucco embossed 5005-H134 aluminum sheet in finish and color to match louvers.
2. Frames: 6063-T52 extruded aluminum sections 0.080 inch thick, with mitered corners.
3. Perimeter Gaskets: Closed-cell PVC, to ensure tight fit of panel to louver.
4. Thickness: 2 inches.
5. U-Value: 0.10.

2.04 SOURCE QUALITY CONTROL

A. Factory Performance Tests:

1. Airflow versus pressure loss.
2. Rain penetration data.

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PART 3 EXECUTION

3.01 EXAMINATION

A. Check openings to ensure dimensions conform to Drawings.

B. Ensure openings are free of irregularities that would interfere with installation.

C. Do not install louvers until defects have been corrected.

3.02 INSTALLATION

A. Install louvers as shown on reviewed Shop Drawings. Coordinate with heating or ventilation ductwork to be connected.

B. Follow procedures in manufacturer’s recommended installation instructions.

C. Install insulated blank-off panels where indicated, completely closing space between ducts and louver frames.

D. Separate aluminum from other metals with isolation tape or paint.

3.03 CLEANING

A. After erection, protect exposed portions from damage by machines, paint, lime, acid, cement, or other harmful compounds.

B. Remove protective materials and clean with plain water, water with soap, or household detergents.

END OF SECTION

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SECTION 09 29 00
GYPSUM BOARD

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American National Standards Institute (ANSI): A118.9, Test Methods and Specifications for Cementitious Backer Units.
2. ASTM International (ASTM):
   a. A641/A641M, Standard Specification for Zinc-Coated (Galvanized) Carbon Steel Wire.
   b. C208, Standard Specification for Cellulosic Fiber Insulating Board.
   c. C475/C475M, Standard Specification for Joint Compound and Joint Tape for Finishing Gypsum Board.
   d. C514, Standard Specification for Nails for the Application of Gypsum Board.
   e. C645, Standard Specification for Nonstructural Steel Framing Members.
   f. C665, Standard Specification for Mineral-Fiber Blanket Thermal Insulation for Light Frame Construction and Manufactured Housing.
   g. C754, Standard Specification for Installation of Steel Framing Members to Receive Screw-Attached Gypsum Panel Products.
   h. C840, Standard Specification for Application and Finishing of Gypsum Board.
   i. C1002, Standard Specification for Steel Self-Piercing Tapping Screws for the Application of Gypsum Panel Products or Metal Plaster Bases to Wood Studs or Steel Studs.
   j. C1047, Standard Specification for Accessories for Gypsum Wallboard and Gypsum Veneer Base.
   k. C1177/C1177M, Standard Specification for Glass Mat Gypsum Substrate for Use as Sheathing.
   l. C1178/C1178M, Standard Specification for Glass Mat Water-Resistant Gypsum Backing Panel.
   m. C1396/C1396M, Standard Specification for Gypsum Board.
   n. D4977, Standard Test Method for Granule Adhesion to Mineral Surfaced Roofing by Abrasion.
   o. D5420, Standard Test Method for Impact Resistance of Flat, Rigid Plastic Specimen by Means of a Striker Impacted by a Falling Weight (Gardner Impact).

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p. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
q. E90, Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements.
r. E119, Standard Test Methods for Fire Tests of Building Construction and Materials.
s. E413, Classification for Rating Sound Insulation.
t. E695, Standard Test Method of Measuring Relative Resistance of Wall, Floor, and Roof Construction to Impact Loading.
u. F1233-98 Standard Test Method for Security Glazing Materials And Systems.

3. Gypsum Association (GA):
   a. 214, Recommended Levels of Gypsum Board Finish.
   b. 216, Application and Finishing of Gypsum Panel Products.
4. Underwriters Laboratories Inc. (UL): UL Fire Resistance Directory.
   a. UL752 Standard for Bullet Resisting Equipment – Level 4.

1.02 SUBMITTALS

A. Submittals:

1. Control joint pattern proposed for gypsum board.
2. Manufacturer's list of items and materials proposed for use, with descriptive literature for each system used.
3. Manufacturer's Fastener Pattern for anchoring FRP Panels.

1.03 QUALITY ASSURANCE

A. General: Regardless of the minimum specifications herein, utilize materials and applications recommended by manufacturer.

B. Applicator's Qualifications: Use only workers regularly employed in this type of work who can show experience in application of similar materials and specific systems specified.

C. Single Source Responsibility: Use gypsum board and related joint treatment materials from a single manufacturer for each type used.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Delivery: Deliver fire-rated materials bearing testing agency label and required fire classification numbers.

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B. Storage:

1. Store materials inside, under cover, stacked flat, off floor.
2. Stack gypsum board so that long lengths are not over short lengths.
3. Avoid overloading floor system of storage area.
4. Store adhesives and finishing compounds in dry areas; protect against freezing at all times.

1.05 ENVIRONMENTAL CONDITIONS

A. Temperature: In areas receiving gypsum board installation, maintain minimum temperature of 40 degrees F for 48 hours before, during, and after gypsum board application. Maintain minimum temperature of 50 degrees F for 48 hours before, during, and after application of adhesive methods of attachment and finishing compounds until drying is complete.

B. Ventilation:

1. Provide ventilation during and following adhesives and joint treatment applications.
2. Use temporary air circulators in enclosed areas lacking natural ventilation.
3. Under slow drying conditions, allow additional drying time between coats of joint treatment.
4. Protect installed materials from drafts of ambient air during hot, dry weather.
5. Protect materials from drying too rapidly during hot and dry weather.

PART 2 PRODUCTS

2.01 GYPSUM BOARD

A. Fire-Rated Board (GWBX): ASTM C1396/C1396M, Type X, 5/8-inch thick with, tapered edges.

B. Water-Resistant Board (WRB): ASTM C1396/C1396M, 5/8-inch thick with tapered edges.

C. Abuse Resistant Board (ARWB): ASTM C1396/C1396M, Type X, 5/8-inch thick as manufactured by:

1. National Gypsum Company; Gold Bond Hi-Abuse Wallboard.
2. United States Gypsum Co.; SHEETROCK Brand Abuse-Resistant Gypsum Panels.

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2.02 TILE BACKING PANELS

A. Cementitious Backer Board (CBB):

1. Aggregated portland cement panel reinforced with vinyl-coated, woven fiberglass mesh embedded in both surfaces meeting ANSI A118.9.
2. Thickness: Type X, 5/8-inch.
3. Manufacturers and Products:
   a. Custom Building Products; Wonderboard.
   b. United States Gypsum; Durock.

2.03 BULLET RESISTANT FIBERGLASS PANELS (FRP PANELS)

A. Ballistic grade fiberglass panels: flat rigid sheets, designed to block and or capture a penetrating projectile.

B. Performance Level;

1. Bullet Resistance Tested: Meet requirements of UL752 – Level 4.
2. Ammunition Tested: Rifle, .30 caliber lead core, 180 grain, minimum 2450 feet per second.

C. Panel Sizes: Manufacturer's standard widths by nominal 8 feet high.

D. Panel Thickness: Nominal 1-3/8 inch and as required to meet performance level specified.

E. Manufacturer and Product: Waco Products Inc.; ArmorCore UL752 Level 4.

2.04 FASTENERS

A. Gypsum Board:

1. Screws: ASTM C1002, self-drilling, self-tapping, bugle head, for use with power-driven tool.
   a. Type S, 1 inch long for gypsum board to sheet metal.
   b. Type W, 1-1/4 inches long for gypsum board to wood.

B. Glass Mesh Mortar Units/Cementitious Backer Board:

1. Screws: ASTM C1002, self-drilling, self-tapping, bugle head, for use with power-driven tool.
   a. Type S, 1-1/4 inch, Hi-Lo for wood or 22-gauge to 25-gauge steel framing.

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b. Type S-12, 1-1/4 inch, for 14-gauge to 20-gauge steel framing; 1-15/16 inch.
c. Type S-12, Pilot Point for steel joists.

C. FRP Panels – Fasteners and spacing as recommended by panel manufacturer.

2.05 JOINT TREATMENT MATERIALS

A. Tape:

1. General Interior Applications: ASTM C475/C475M, perforated paper tape.

B. Compound:

1. General Interior Applications: ASTM C475/C475M, all-purpose, ready-mixed compound.
2. Water-Resistant GWB: Chemically curing, polyindurate type material as recommended by manufacturer.

2.06 ANCILLARY MATERIALS

A. Adhesives: As recommended by gypsum board manufacturer for intended use. Use adhesives that have VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Sound Attenuation Blankets: ASTM C665, Type I (no facing), 3 inches thick.

C. Acoustical Sealant:

1. Nonsetting and nonstaining **[A: with a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24)].**
2. Manufacturers:
   a. DAP.
   b. United States Gypsum.
   c. Tremco.
   d. Ohio Sealants, Inc.

2.07 TRIM ACCESSORIES

A. ASTM C1047, Zinc-Coated Metal.

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B. Manufacturers and Products:

1. Corner Bead:
   a. 1-1/4 inches by 1-1/4 inches:
      1) United States Gypsum; Dur-A-Bead.
      2) Gold Bond; standard corner beads.
2. Edge Trim:
   a. United States Gypsum; 200B metal trim.
   b. Gold Bond; No. 200 casing bead.
3. Metal Control Joint:
   a. United States Gypsum; No. 093.
   b. Gold Bond; E-Z strip control joint.

2.08 NONSTRUCTURAL METAL FRAMING MEMBERS

A. ASTM C645, galvanized C-studs with 1-5/8-inch flanges.

B. Sizes and Gauge: As noted in wall types on Drawings.

C. Manufacturers:

1. United States Gypsum.
2. Dale/Incor.
3. Gold Bond.
4. Unimast, Inc.

2.09 LIGHT-GAUGE METAL FRAMING ACCESSORIES

A. Cold-Rolled Carrying Channel: Cold-rolled steel, 18-gauge metal with minimum 1/2-inch wide flange, galvanized, 2 inches deep.

B. Cold-Rolled Furring Channel: Cold-rolled steel, 25-gauge metal with minimum 1/2-inch wide flange, galvanized depth as shown or as required.

C. Z-Furring: Galvanized 20-gauge, depth as shown or as required.

D. Hat-Shaped Furring Channels: Roll-formed hat shaped section of 20-gauge galvanized steel with a face width of 1-1/4 inches and a depth of 7/8 inch(es).

E. Hanger Wire: ASTM A641/A641M, Class 1 zinc coating, soft temper, 0.162-inch diameter.

F. Tie Wire: ASTM A641/A641M, Class 1 zinc coating, soft temper, 0.625-inch diameter or double strand of 0.0475-inch diameter wire.

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2.10 DRY WALL CEILING SUSPENSION SYSTEM

A. Use system of main runners, cross tees, and furring channels.

B. Manufacturers:

1. Armstrong World Industries, Inc.; Furring Systems/Drywall.
2. USG Interiors, Inc.; Drywall Suspension System.

2.11 SPRAY TEXTURE

A. Manufacturers and Products:

B. Manufacturers and Products:

1. Nonaggregate Finish:
   a. National Gypsum Company; ProForm Perfect Spray EM/HF.
   b. United States Gypsum Co.; SHEETROCK Wall and Ceiling Spray Texture (unaggregated).

PART 3 EXECUTION

3.01 EXAMINATION

A. Inspect surfaces to receive gypsum board and related materials before beginning work and report to Engineer any defects in such work which will adversely affect the quality of work specified herein.

3.02 PREPARATION

A. General: Provide, install, and maintain necessary scaffold, staging, trestles, planking, and temporary heating, lighting, and ventilation as necessary for duration of gypsum board work.

B. Protection: Protect work of other trades.

C. Coordination:

1. Coordinate work with that of other trades. Check specifications and drawings of other trades to determine parts of work requiring coordination.
2. Cut and repair gypsum board systems for installation of omitted work.

D. Surface Preparation: Repair defective surfaces prior to starting work. Prepare as specified for application of specific materials.

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3.03 ERECTION OF DRY WALL CEILING SUSPENSION SYSTEM

A. Follow manufacturer's printed instructions.

B. Hangers:

1. Space not over 4 feet OC in direction of runners and within 6 inches of ends of runners.
2. Securely attach to structure above and provide for full saddle tie to main runner at indicated height.
3. Connections shall develop full strength of hanger wire.

C. Bracing:

1. Securely brace ceiling areas against sway.
2. Where required by code, install for seismic control.
3. Prevent runner and furring channels from contacting masonry walls.

D. Where ducts interfere with normal spacing of hangers and carrying channels, install additional hangers and channels to properly suspend ceiling.

3.04 ERECTION OF LIGHT-GAUGE NONSTRUCTURAL METAL FRAMING

A. Layout: Align partitions as shown on Drawings.

B. Tracks:

1. Attach metal runner tracks to floor slabs with suitable fasteners located 2 inches from each end and spaced not more than 24 inches OC.
2. Where partitions terminate at suspended or framed ceilings attach top tracks to suspended ceiling with toggle or molly bolts spaced 24 inches OC.
3. Where partitions terminate above suspended ceilings provide diagonal bracing from top of partitions to structure above. Bracing shall be 3-5/8-inch metal studs staggered at 48 inches OC.
4. Where partitions terminate at underside of concrete or metal decking attach deflection channels to substrate with suitable fasteners located 2 inches from each end and spaced not more than 24 inches OC. Locate partition top tracks within deflection channels with a minimum top clearance of 1 inch. Do not attach track to channel.

C. Studs:

1. ASTM C754.
2. Following manufacturer's printed instructions, position studs vertically, engaging floor and ceiling tracks and spaced as noted on Drawings.

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3. Splice: When necessary, use 8-inch nested lap and one positive attachment per stud flange.
4. Place in direct contact with doorframe jambs, abutting partitions, and partition corners. Provide for anchorage of doorframes to studs.
5. Anchor studs for shelf-walls and those adjacent to window and doorframes, partition intersections, and corners to ceiling and floor runner flanges. Securely anchor studs to jamb and head anchor clips of door or borrowed-light frames by bolt or screw attachment.
6. Over metal door and borrowed-light frames, place horizontally a cut-to-length section of runner, with a web-flanged bend at each end, and secure with one positive attachment per flange. Position a cut-to-length stud (extending to ceiling runner) at vertical panel joints over doorframe header.
7. Locate studs at abutting construction, partition intersections, and partition corners.
8. Spacing: At 16 inches OC, unless otherwise required by manufacturer.
9. At Doorframes and Cased Openings:
    a. Full height double studs, No. 20 gauge minimum, secured to jamb anchors by bolts, screws, or welds.
    b. Header Track: Secure to frame head anchors and double studs.
    c. Provide double channel stiffeners through studs above frame and extend at least one stud space beyond each jamb.
10. Windows: Similar framing to door openings with stiffeners both above and below.
11. Wall Mounting Accessories: Provide channels, horizontal studding, No. 16 gauge sheet 8 inches by 2 inches greater than stud spacing, or other members within walls as required to provide secure and adequate support.

D. Furring:

1. Space furring channels the same as studs or as shown.
2. Around columns and beams construct furring as shown using metal studs and furring channels securely tied together and anchored in-place.
3. Attach resilient furring channels to wood framing with screws.

3.05 APPLICATION OF GYPSUM BOARD

A. Inspection and Preparation:

1. Check framing for accurate spacing and alignment.
2. Verify spacing of installed framing does not exceed maximum allowable for thickness of gypsum board to be used.
3. Verify frames are set for thickness of gypsum board to be used.
4. Do not proceed with installation of gypsum board until deficiencies are corrected and surfaces to receive gypsum board are acceptable.

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5. Repair protrusions of framing, twisted framing members, or unaligned members before installation of gypsum board is started.

B. General:

1. Meet requirements of ASTM C840 and GA 216.
2. Joints: Use gypsum board of maximum lengths to minimize end joints. Stagger end joints when they occur. Locate end joints as far as possible from center of wall or ceiling. Abut gypsum board without forcing. Neatly fit ends and edges of gypsum board. Do not place butt ends against tapered edges.
3. Support ends and edges of gypsum board panels on framing or furring members except for face layer of double layer and where ends are back blocked and floated.
4. Use metal edge trim where gypsum board abuts another material, at corners, and where shown or noted on Drawings.
5. Follow manufacturer's recommendation of good practice.

C. Over Framing:

1. Apply gypsum board first to ceiling and then to walls for single layer horizontal application.
2. Use vertical application for fire-rated walls.
3. Fasten gypsum board securely to framing using double nailing, screw, or adhesive method.

D. Sound-Rated Partitions:

1. Fabricate and erect in accordance with manufacturer's printed instructions for required rating.
2. Install sound-deadening board and attenuation blankets as detailed.
3. Seal with acoustical sealant perimeter edges of gypsum board, joints around penetrations, and other joints as noted.

3.06 APPLICATION OF CEMENTITIOUS BACKER BOARD (CBB)

A. Follow manufacturer's printed instructions for erection, cutting, attachments, and joint treatment.

B. Verify framing is installed at maximum 16 inches OC, and necessary blocking to support fixtures and accessories has been installed. Where backing plates or straps are used, space out from framing to ensure a smooth finish application. Do not proceed until defects are corrected and are acceptable.

C. Precut boards to required sizes and make necessary cutouts. Fasten with appropriate fasteners. Space fasteners 6 inches OC maximum or as directed by manufacturer. Fit ends closely but not forced together. Maintain 1/4-inch

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spacing between edge of board and fixture. Caulk all joints and corners that are to receive tiles. Apply 2-inch glass fiber tape over joints and corners embedded with tile setting mortar.

3.07 JOINT SYSTEM FOR GYPSUM WALLBOARD

A. Interior Gypsum Board: Conform to ASTM C840.

B. Required: On exposed gypsum board, under ceramic tile and wall covering, and behind casework.

C. Prefill: Fill V-grooves formed by abutting rounded edges of gypsum board with prefill joint compound. Fill V-joint flush and remove excess compound beyond groove. Leave clear depression to receive tape. Permit prefill joint compound to harden prior to application of tape.

D. Taping and Finishing Joints:

1. Taping or Embedding Coat: Apply compound in thin, uniform layer to joints and angles to be reinforced. Apply reinforcing tape immediately. Center tape over joint and seat tape into compound. Leave approximately 1/64-inch to 1/32-inch compound under tape to provide bond. Apply skim coat immediately following tape embedment but not to function as fill or second coat. Fold tape and embed in angles to provide true angle. Dry embedding coat prior to application of fill coat.
2. Filling Coat: Apply joint compound over embedding coat. Fill taper flush with surface. Apply fill coat to cover tape. Feather out fill coat beyond tape and previous joint compound line. For joints with no taper, feather out at least 4 inches on either side of tape. Do not apply fill coat on interior angles. Allow fill coat to dry prior to application of finish coat.
3. Finishing Coat: Spread joint compound evenly over and beyond fill coat on joints. Feather to smooth uniform finish. Apply finish coat to taped angles to cover tape and taping compound. Sand final application of compound to provide surface ready for decoration.
4. Filling and Finishing Depressions: Apply joint compound as first coat to fastener depressions. Apply at least two additional coats of compound after first coat is dry. Leave filled and finished depressions level with plane of surface.

E. Finishing Beads and Trim:

1. First Fill Coat: Apply joint compound to bead and trim. Feather out from ground to plane of the surface. Dry compound prior to application of second fill coat.

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2. Second Fill Coat: Apply joint compound in same manner as first fill coat. Extend beyond first coat onto face of gypsum board. Dry compound prior to application of finish coat.
3. Finish Coat: Apply joint compound to bead and trim. Extend beyond second fill coat. Feather finish coat from ground to plane of surface. Sand finish coat to provide flat surface ready for decoration.

3.08 FINAL FINISHES FOR GYPSUM WALLBOARD

A. Levels of Finish: Conform to GA 214.

B. Level 1:

1. Taping or embedding coat only.
2. Use in concealed areas, and where indicated, unless a higher level is required for fire-resistive or sound-rated assemblies.

C. Level 2:

1. Taping, filling, and finishing coats.
2. Use on water-resistant gypsum backing board.

D. Level 3:

1. Taping, filling, and finishing coats.
2. Use on surfaces indicated to have spray texture or ceramic tile.

E. Level 4:

1. Taping, filling, and finishing coats plus two separate coats applied over joints, angles, fastener heads, and trim accessories.
2. Sand between coats and after last coat.
3. Use on surfaces indicated to receive wall coverings.

F. Level 5:

1. Same as Level 4, plus a thin, smooth, uniform skim coat of joint compound, or product specially formulated for this purpose, over entire surface.
2. Produce surfaces free of tool marks and ridges, ready for decoration.
3. Use on surfaces not indicated otherwise, those indicated to receive gloss, semi-gloss, and nontextured flat paints, and where indicated.

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3.09 SPRAY TEXTURE

A. Application:

1. Apply on gypsum board wall and ceiling surfaces, except behind ceramic tile and wall covering, following manufacturer's printed directions for a medium build orange peel texture.
2. Before texture application, finish gypsum board as specified for Level 3.
3. When surfaces are prepared and dry, apply sealer and allow to dry. Mix texture finish material as directed by manufacturer.
4. Use spray equipment of a size and type to assure acceptable results.
5. Apply by spray only at a coverage rate as recommended by manufacturer and in accordance with directions printed on container. Apply material to blend uniformly and cover fully without starved spots or other evidence of thin application. Provide uniform texture without application patterns.

3.10 ADJUST AND CLEAN

A. Clean: Remove droppings or texture overspray from walls, windows, and floor, leaving room clean for following trades.

B. Nail Pop: Repair nail pop by driving new nail approximately 1-1/2 inches from nail pop and reseat nail. When face paper is punctured, drive new nail or screw approximately 1-1/2 inches from defective fastening and remove defective fastening. Fill damaged surface with compound.

C. Ridging:

1. Do not repair ridging until condition has fully developed, approximately 6 months after installation or one heating season.
   a. Sand ridges to reinforcing tape without cutting through tape.
   b. Fill concave areas on both sides of ridge with topping compound.
   c. After fill is dry, blend in topping compound over repaired area.
2. Fill cracks with compound and finish smooth and flush.

3.11 APPLICATION OF FRP PANELS

A. Anchor direct to metal building base channels and sidewall girts following panel manufacturer's installation instructions.

B. Provide batten backing at panel joints for ballistic protection full width of wall area.

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C. Follow panel manufacturer’s instructions for anchoring and fastener spacing.

D. Provide flush wall surface ready for painting or mounting of electrical equipment.

END OF SECTION

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SECTION 09 30 00
TILING

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American National Standards Institute (ANSI):
   a. A108.4A108.5, Installation of Ceramic Tile with Dry-Set Portland Cement Mortar or Latex-Portland Cement Mortar.
   b. A108.6
   c. A108.10, Installation of Grout in Tilework.
   d. A108.11, Interior Installation of Cementitious Backer Units.
   e. A118.1, Dry-Set Portland Cement Mortar.
   f. A118.4, Latex-Portland Cement Mortar.
   g. A118.6, Standard Cement Grouts for Tile Installation.
2. ASTM International (ASTM):
   a. C144, Standard Specification for Aggregate for Masonry Mortar.
   b. C150, Standard Specification for Portland Cement.
   c. C206, Standard Specification for Finishing Hydrated Lime.
   d. C207, Standard Specification for Hydrated Lime for Masonry Purposes.
   e. C920, Standard Specification for Elastomeric Joint Sealants.
3. Tile Council of North America (TCA): Handbook for Ceramic Tile Installation.

1.02 SUBMITTALS

A. Action Submittals:

1. Samples:
   a. Three for each color, pattern, and type of tile specified.
   b. Size: One full size tile.
   c. Mark Samples clearly to indicate color or shade, location in which to be used, and manufacturer’s name.

B. Informational Submittals:

1. Certification of Compliance: For tile, mortar, grouts, and adhesives.
2. Manufacturer’s Instructions: For storage, mixing, application, cleanup, and use of proposed mortars, grouts, and adhesives.
3. Tile Manufacturer’s Maintenance Guidelines: For Owner’s use in maintaining ceramic tilework specified herein.

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1.03 QUALITY ASSURANCE

A. Perform Work in accordance with TCA Handbook and ANSI A108 Series/A118 Series.

B. Mock-up and Layout:

1. Construct mock-up with vertical portion 4 feet long by 4 feet wide and horizontal potion 8 inches wide, with finish grout. Include all tile types, colors and shapes to simulate design. Mock-up shall include inside and outside wall corners as well as wall to floor joints. The accepted mock-up will serve as a standard of workmanship by which similar work will be evaluated.
2. Locate where directed by Engineer and do not remove mock-up until directed by Engineer.
3. Prior to commencing installation of tile, erect layout lines demonstrating proposed tile joint locations and cut tiles for approval by Engineer.

1.04 ENVIRONMENTAL REQUIREMENTS

A. Set and grout tile in portland cement mortar when ambient temperature is at least 50 degrees F and rising. Follow ANSI A108.1A or ANSI A108.1B, as recommended by ANSI A108.1C.

B. Comply with minimum temperature recommendations of manufacturers for bonding and grouting materials other than portland cement mortar.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Materials and products specified in this section shall be products of:

1. American Olean Tile Co.
2. Dal-Tile Corp.

2.02 MATERIALS

A. Tile: Standard grade, ANSI A137.1.

B. Unglazed Ceramic Mosaic Floor Tile: ANSI A137.1, Section 5.1, porcelain type, smooth cushion edge, nominal face size 2 inches by 2 inches, patterns as shown and colors as scheduled on Drawings.

C. Glazed Ceramic Mosaic Wall Tile: ANSI A137.1, Section 6.2, porcelain type, cushion edge, nominal face size 2 inches by 2 inches, face finished with bright glazed finish, patterns as shown and colors as scheduled on Drawings.

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D. Cove Bases: Type, color, and finish to match floor tiles.

E. Latex-Portland Cement Mortar: ANSI A118.4.

F. Commercial Portland Cement Grout: White, L & M Acid-R or Upco Hydroment.

2.03 ANCILLARY MATERIALS

A. Expansion Joints:

1. Sealant: Silicone rubber type, meeting ASTM C920, Type S, Grade P, Class 25, Use T, color to match grout, with Shore A hardness of minimum 25 for joints in horizontal surfaces and minimum 35 in traffic areas.
2. Backup Material: Flexible and compressible type, nonstaining and compatible with sealants used.

B. Sealer: Hillyard Chemical Co., Cemseal II or Thompson's Water Seal 101.

C. Tile Cleaner: Neutral tile cleaner solution acceptable to tile manufacturer.

D. Construction Paper: Heavy-duty, nonstaining kraft paper.

PART 3 EXECUTION

3.01 PREPARATION

A. Examine surfaces to receive ceramic tile, setting beds, or accessories prior to tile installation.

B. Correct defects or adverse conditions affecting quality and execution of tile installation.

C. Surfaces to receive tile shall be plumb, level, and true with square corners.

D. Tolerances for Surfaces to Receive Tile:

1. Portland Cement, Dry-Set, Methods:
   a. Maximum Variation in Subfloor Surface: 1/4 inch in 10 feet.
   b. Maximum Variation in Vertical Surfaces: 1/4 inch in 8 feet.

E. Grounds, anchors, plugs, hangers, bucks, electrical and mechanical work, in or behind tile, to be installed prior to proceeding with tilework.

F. Protection: Protect adjoining work surfaces before tilework begins.

G. Make substrate firm, dry, clean, and free of oily or waxy films.

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3.02 INSTALLATION

A. Prepare surfaces, fit, set, or bond tile, grout and clean tile in accordance with applicable requirements of ANSI Standards for setting method specified, except as otherwise noted.

B. Workmanship, Cutting, Fitting, and Grout Joint Size:

1. Center and balance areas of tile.
2. Generally start full size tiles at outside corners and leave cut tiles for inside corners.
3. Tile Cutting:
    a. Minimize number of cuts.
    b. No cuts smaller than half size without approval of Engineer.
    c. Make all cuts on the outer edges of the field.
    d. Smooth cut edges. Install tile without jagged or flaked edges.
    e. Do not split tile unless no other alternative is possible.
4. Fit tile closely where edges will be covered by trim, escutcheons, or other similar devices.
5. Maintain heights of tile work in full courses to nearest obtainable dimension where heights are given in feet and inches and are not required to fill vertical spaces exactly.
6. Grout Joint Size: 1/8 inch.
7. Install accessories in tile work to be evenly spaced, properly centered with tile joints, and level, plumb, and true to the correct projection. Install accessories at locations and heights shown or designated.

C. Trim: Provide coves, bases, caps, stops, returns, trimmers, and other shapes to finish installation.

D. Setting Wall Tile (Thin-Set Application):

1. On Concrete or Masonry: Meet TCA Method W202.
2. On Cementitious Backer Board Over Metal Studs: Meet TCA Method W243.
3. Use latex-portland cement grout.

E. Setting Floor Tile (Thin-Set Application):

1. On Concrete: Meet TCA Method F113 with latex-portland cement grout.

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3.03 CLEANING AND SEALING

A. Clean tile surfaces thoroughly on completion of grouting.

B. Remove grout haze, observing tile manufacturer’s recommendations as to use of acid and chemical cleaners.

C. Rinse tilework thoroughly with clean water before and after using chemical cleaners.

D. Polish surface of glazed tilework with soft cloth.

E. After grout has cured for 10 days, clean and seal nonglazed tiles following sealer manufacturer’s instructions and recommendations.

3.04 PROTECTION

A. From Construction Dirt:

1. Apply protective coat of neutral cleaner solution, one part cleaner to one part water, to clean completed tile walls and floors.
2. Cover tile floors with heavy-duty, nonstaining construction paper, masked in-place.
3. Just before substantial completion, remove paper and rinse protective coat of neutral cleaner from tile surfaces.

B. From Traffic:

1. Prohibit foot and wheel traffic from using newly tiled floors for at least 7 days.
2. Place large, flat boards in walkways and wheelways for 7 days where use of newly tiled floor with cement type grout is unavoidable.

END OF SECTION

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SECTION 09 51 13
ACOUSTICAL PANEL CEILINGS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards that may be referenced in this section:

1. ASTM International (ASTM):
   a. A641/A641M, Standard Specification for Zinc-Coated (Galvanized) Carbon Steel Wire.
   b. C635/C635M, Standard Specification for the Manufacture, Performance, and Testing of Metal Suspension Systems for Acoustical Tile and Lay-In Panel Ceilings.
   c. C636/C636M, Standard Practice for Installation of Metal Ceiling Suspension Systems for Acoustical Tile and Lay-In Panels.
   d. E1264, Standard Classification for Acoustical Ceiling Products.
2. Underwriters Laboratories Inc.(UL): Fire Resistance.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Detailed layout of grid indicating hanger spacing, fastening and splicing details, change in level details, and access location.
2. Samples:
   a. One 12-inch square of each acoustical unit material to illustrate range of appearance.
   b. One full-size Sample of each suspension system member and molding.
   c. Mark with manufacturer’s name and specific design and technical data.
3. Manufacturer’s recommendation for installation of system.

1.03 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials with manufacturer’s labels indicating brand name, pattern, and size.

B. Store materials in original protective packaging to prevent soiling, physical damage, or wetting.

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1.04 ENVIRONMENTAL REQUIREMENTS

A. Where acoustical materials are to be installed, maintain humidity of 65 percent to 75 percent in area for 25 hours before, during, and 25 hours after installation.

B. Maintain uniform temperature of 55 degrees F to 70 degrees F prior to and during installation of materials.

PART 2 PRODUCTS

2.01 SUSPENSION SYSTEMS

A. Components, Materials, and Accessories: Product of a single manufacturer.

B. ASTM C635/C635M, Heavy Duty:

1. Exposed Tee Grid: Fire-rated spaced to fit lay-in panels.
   a. Manufacturers and Products:
      1) Chicago Metallic Corp.; Fire Front 1265 System.
      2) Armstrong; Prelude Plus XL Fire Guard.
2. Main and Cross Members:
   a. Double web design, cold-rolled steel, minimum thickness of 0.020 inch, electrozinc-coated and factory-painted low-sheen satin white finish.
   b. Exposed Flange Width: 15/16 inch.
3. Edge Molding:
   a. Minimum 0.020-inch steel, channel- or angle-shaped.
   b. Flange Width: 15/16 inch minimum.
   c. Finish to match main members.
4. Hanger Wire: ASTM A641/A641M, minimum 12-gauge, galvanized, soft-annealed, mild steel wire.
5. Wire Ties: ASTM A641/A641M, 18-gauge, galvanized, annealed steel wire.

2.02 ACOUSTICAL UNITS

A. Flat Lay-In Panels:

1. Material: Fire-resistive mineral fiber, Class A.
2. In accordance with ASTM E1264, Type III, Form 2.
3. Pattern: Random fissured.
4. Noise Reduction Coefficient (NRC): 0.55 to 0.65.
5. Ceiling Attenuation Class (CAC): 35 minimum.
6. Light Reflectance: LR 0.75 or over.
7. Nominal Size: 24 inches by 24 inches by 5/8 inch thick.
8. Edges: Square.

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9. Finish and Color: Painted white, unless scheduled otherwise.
10. Manufacturers and Products:
    a. Armstrong; Item 895, Minaboard, Cortega.
    b. Celotex; Item PBT-197, Hytone, Baroque.
    c. U.S.G.; Item 56705, Auratone, Natural Fissured II.

PART 3 EXECUTION

3.01 SEQUENCING

A. Lay out grid.

B. Coordinate with mechanical and electrical equipment in framing and cutting material around ceiling penetrations.

C. Install suspension systems after mechanical work above is complete.

D. Install acoustical units.

3.02 INSTALLATION OF SUSPENDED GRID SYSTEM

A. Hang level and in straight alignment directly from structure in accordance with ASTM C636/C636M and manufacturer's printed instructions.

B. Hanger Wires:

1. Space maximum 4 feet on center each direction and securely attach to structure above.
2. Install additional hangers at ends of each suspension member and at light fixtures, 6 inches from vertical surfaces.
3. Do not splay wires more than 5 inches in a 4-foot vertical drop.
4. Provide four-way wire splays at 45 degrees from main runner to support structure for every 144 square feet of ceiling area.
5. Wrap wire minimum three times horizontally, turning ends upward.
6. Where hanger wires cannot be hung vertically from structure above because of ducts, pipes, cable trays, or other interferences, provide steel channel trapezes (minimum 2-inch deep, 16-gauge cold-rolled carrying channels) hung on steel rods or 8-gauge wire from structural members above. Hang ceiling wires from these trapezes or similar members supporting ducts or pipes. Do not hang directly from ducts or pipes.
7. Follow suspension system manufacturer's instructions for modified installation required for Seismic Design Category indicated in General Structural Notes on Drawings.

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C. Edge Molding:

1. Install at intersection of suspended ceiling and vertical surfaces.
2. Miter corners where moldings intersect or install corner caps.
3. Attach to vertical surface with mechanical fasteners.

D. Provide additional channels, hangers, and trapezes as required to support edges of ceiling around and under mechanical and electrical work.

3.03 INSTALLATION OF ACOUSTICAL UNITS

A. Upon completion of suspended grid system and other concealed work, install with pattern running in one direction.

B. Place material to bear all around on suspension members.

3.04 CLEANING

A. Clean soiled or discolored unit surfaces after installation.

B. Touch up scratches, abrasions, voids, and other defects in painted surfaces.

3.05 SCHEDULE OF CEILING TYPES

A. Areas to Receive Acoustical Ceilings: Indicated on Interior Finish Schedule located on Drawings by type described below.

B. Acoustical Ceiling Type 1 (ACT):

1. Suspension System: Exposed painted steel tee grid system, 24 inches by 24 inches.
2. Exposed grid with main runners at 24 inches on center and cross tees at 24 inches on center.
3. Lay out grid to provide symmetrical borders and which are not less than half the size of the lay-in panels.
4. Acoustical Units: Flat lay-in panels.

END OF SECTION

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SECTION 09 65 00
RESILIENT FLOORING

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   a. D412, Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers - Tension.
   b. D570, Standard Test Method for Water Absorption of Plastics.
   c. D2407, Standard Test Method for Static Coefficient of Friction of Polish-Coated Flooring Surfaces as Measured by the James Machine.
   d. E648, Test Method for Critical Radiant Flux of Floor Covering Systems Using a Radiant Energy Source.
   e. E662, Test Method for Specific Density of Smoke Generated by Solid Materials.
   f. F970, Test Method for Static Load Limit.
   g. F1861, Standard Specification for Resilient Wall Base.
   h. F2195, Standard Specification for Linoleum Floor Tile.
2. National Fire Protection Association (NFPA):
   a. 253, Test Method for Critical Radiant Flux of Floor Covering Systems Using a Radiant Energy Source.
   b. 258, Test Method for Specific Density of Smoke Generated by Solid Materials.

1.02 SUBMITTALS

A. Action Submittals:

1. Samples:
   a. Three full-size tiles for each type and color of resilient flooring as scheduled on Drawings.
   b. Three 2-1/2-inch wide strips of base material for each type and color scheduled on Drawings.

B. Informational Submittals:

1. Manufacturer’s certificate of compliance.
2. Operation and Maintenance Data:
   a. As specified in Section 01 78 23, Operation and Maintenance Data.

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b. List of recommended maintenance products, methods, and procedures.

1.03 DELIVERY, STORAGE, AND HANDLING

A. Store materials in original containers at not less than 70 degrees F ambient temperature for not less than 24 hours immediately before installation.

1.04 ENVIRONMENTAL REQUIREMENTS

A. Maintain ambient temperature in space to receive flooring between 70 degrees F and 90 degrees F for not less than 24 hours before and 48 hours after installation.

B. Maintain minimum temperature of 55 degrees F after flooring is installed, except as specified above.

1.05 SEQUENCING AND SCHEDULING

A. Do not install floor coverings until concrete slab has cured for 60 days or until primer material in test patches cannot be scraped or peeled from the slab after drying 24 hours.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Flooring products of the following manufacturers, meeting these Specifications, may be used on this Project:

1. Armstrong World Industries, Inc.
2. Burke Flooring Products.
3. Congoleum Corp.
4. Forbo Flooring Systems.
5. Johnsonite, Division of Duramax, Inc.
6. Roppe.

2.02 FLOOR COVERING MATERIALS

A. General: Furnish materials uniform in thickness and size with edges cut accurately and square; uniform color with variations in variegated patterns kept to a minimum.

B. Linoleum Tile (LINO):

1. Performance Requirements:
   a. Meet ASTM F2195.
   b. Static Coefficient of Friction: ASTM D2047.

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c. Static Load Limit: ASTM F970.
d. Fire Performance:
1) Flooring Radiant Panel: Class 1, rating per NFPA 253 (ASTM E648).
2) Smoke Density: Less than 450 per NFPA 258 (ASTM E662).
2. Size: 13-inch by 13-inch.
3. Gauge: 1/10-inch.
4. Backing Material: Polyester.
5. Manufacturers and Products:
a. Armstrong; Linoleum Tile.
b. Forbo; MCT Linoleum.

2.03 RESILIENT BASE

A. General: ASTM F1861, uniform in 0.125-inch thickness and in as long lengths as practicable to suit conditions of installation.

1. Factory premolded internal and external corners to match base when available.
2. Rubber Base: Type TP, Group 1.
3. Style: B, cove.
4. 4 inches high.

B. Manufacturers and Products:

1. Armstrong; Color-Integrated Wall Base.
2. Roppe; Pinnacle Base.

2.04 ACCESSORIES

A. Reducers:

1. Standard rubber or vinyl floor reducer in thickness to suit abutting floor covering by 1-inch wide, tapered or beveled-edge strip.
2. Manufacturers and Products:
a. Johnsonite; Reducer Series RRS.
b. Mercer; 633 Tile Reducer.

B. Adhesive: Type and brands of adhesive as recommended by manufacturer of floor covering material for conditions of installation.

C. Primer and Crack Filler: Type and brand recommended by floor covering manufacturer.

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D. Floor Filler:

1. Asphalt mastic as manufactured by:
   a. Armstrong, Lancaster, PA.
   b. National Floor Products Co., Florence, AL.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine substrate for excessive moisture content and unevenness preventing execution and quality of resilient flooring as specified.

B. Correct defects before installation of resilient flooring.

3.02 PREPARATION

A. Remove dirt, oil, grease, or other foreign matter from surfaces to receive floor covering materials.

B. Fill cracks less than 1/16-inch wide and depression less than 1/8-inch deep with floor filler.

C. Prime surfaces if recommended by floor covering manufacturer.

3.03 APPLICATION OF ADHESIVES

A. Mix and apply adhesives in accordance with manufacturer’s instructions.

B. Provide safety precautions during mixing and applications as recommended by adhesive manufacturer.

C. Apply uniformly over surfaces:

1. Cover only amount of area that can be covered by flooring material within recommended working time of adhesive.
2. Remove any adhesive that dries or films over.
3. Do not soil walls, bases, or adjacent areas with adhesives.
4. Promptly remove any spillage.

D. Apply adhesives with notched trowel or other suitable tool.

E. Clean trowel and rework notches as necessary to ensure proper application of adhesive.

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3.04 INSTALLATION OF TILE MATERIALS

A. Start tile at center of room or space; work toward perimeter.

B. Do not lay tile less than half the width of a field tile except where accepted by Engineer for irregularly shaped rooms or spaces.

C. Cut border tile neatly and accurately to fit within 1/64 inch of abutting surfaces.

D. Use reducer edge strip at exposed tile edges.

E. Fit flooring material neatly and tightly into breaks and recesses, against bases, around pipes and penetrations, under saddles or thresholds, and around permanent cabinets and equipment.

F. Lay tile parallel to room axis in straight courses with cross joints parallel. Lay tile with grain or pattern running in same direction between adjacent tile.

G. Roll flooring with 75-pound to 100-pound roller in both directions.

3.05 INSTALLATION OF BASE

A. General: Remove defects in wall and floor that would prevent level and true installation of base material.

1. Install base around perimeter of room or space, where shown, and at toe spaces of casework and cabinets.
2. Unroll base material and cut into accurate lengths as desired or as required for minimum number of joints.
3. Match edges at seams or double cut adjoining lengths to give continuous appearance.
4. Install with tight butt joints with no joint widths greater than 1/64 inch.

B. Top-Set Base:

1. Apply adhesive and firmly adhere to wall surfaces.
2. Press down so bottom cove edge follows floor profile.
3. Ensure top and bottom edges of base are in firm contact with walls and floors.
4. Form internal and external corners by using premolded corners. Other methods, acceptable to Engineer, may be used if premolded corners are not available.
5. Scribe base accurately to abutting materials.

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3.06 CLEANING AND PROTECTION

A. Upon completion of the installation of floor covering and adjacent work, and after materials have set, clean surfaces with a neutral cleaner as recommended by manufacturer for type of floor covering material installed.

B. Repair adjacent surfaces damaged by flooring installation.

C. Wax Finishing:

1. Provide wax, cleaner, or other finishing material as recommended by floor covering manufacturer for the particular type of flooring material.
2. Apply one coat of nonslip wax or other finish as recommended by floor covering manufacturer; buff to a sheen.
3. Do not wax radial rubber tile.

D. Protect completed work from traffic and damage until Substantial Completion by covering with plastic sheet, kraft paper, or plywood panels.

3.07 INSTALLATION SCHEDULE

A. Areas to receive resilient flooring, and pattern, are indicated in Interior Finish Schedule on Drawings.

END OF SECTION

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SECTION 09 90 00
PAINTING AND COATING

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Water Works Association (AWWA):
   a. C203, Coal-Tar Protective Coatings and Linings for Steel Water Pipelines—Enamel and Tape—Hot-Applied.
   b. C209, Cold-Applied Tape Coatings for the Exterior of Special Sections, Connections, and Fittings for Steel Water Pipelines.
   c. C213, Fusion-Bonded Epoxy Coating for the Interior and Exterior of Steel Water Pipelines.
   d. C214, Tape Coating Systems for the Exterior of Steel Water Pipelines.
2. Environmental Protection Agency (EPA).
3. NACE International (NACE): SP0188, Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates.
4. NSF International (NSF): 61, Drinking Water System Components - Health Effects.
5. Occupational Safety and Health Act (OSHA).
6. Research Council on Structural Connections (RCSC): Specification for Structural Joints using High-Strength Bolts.
7. The Society for Protective Coatings (SSPC):
   a. PA 2, Procedure for Determining Conformance to Dry Coating Thickness Requirements.
   b. PA 10, Guide to Safety and Health Requirements for Industrial Painting Projects.
   c. SP 1, Solvent Cleaning.
   d. SP 2, Hand Tool Cleaning.
   e. SP 3, Power Tool Cleaning.
   f. SP 5, White Metal Blast Cleaning.
   g. SP 6, Commercial Blast Cleaning.
   h. SP 7, Joint Surface Preparation Standard Brush-Off Blast Cleaning.
   i. SP 10, Near-White Blast Cleaning.
   j. SP 11, Power Tool Cleaning to Bare Metal.
   k. SP 16, Brush-Off Blast Cleaning of Coated and Uncoated Galvanized Steel, Stainless Steels, and Non-Ferrous Metals.
   l. SP 13, Surface Preparation of Concrete.
   m. Guide 15, Field Methods for Retrieval and Analysis of Soluble Salts on Steel and Other Nonporous Substrates.

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1.02 DEFINITIONS

A. Terms used in this section:

1. Coverage: Total minimum dry film thickness in mils or square feet per gallon.
2. FRP: Fiberglass Reinforced Plastic.
3. HCl: Hydrochloric Acid.
4. MDFT: Minimum Dry Film Thickness, mils.
5. MDFTPC: Minimum Dry Film Thickness per Coat, mils.
6. Mil: Thousandth of an inch.
7. PDS: Product Data Sheet.
8. PSDS: Paint System Data Sheet.
9. PVC: Polyvinyl Chloride.
10. SFPG: Square Feet per Gallon.
11. SFPGPC: Square Feet per Gallon per Coat.
12. SP: Surface Preparation.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Data Sheets:
      1) For each product, furnish a Product Data Sheet (PDS), the manufacturer's technical data sheets, and paint colors available (where applicable). The PDS form is appended to the end of this section.
      2) For each paint system, furnish a Paint System Data Sheet (PSDS). The PSDS form is appended to the end of this section.
      3) Technical and performance information that demonstrates compliance with specification.
      4) Furnish copies of paint system submittals to the coating applicator.
      5) Indiscriminate submittal of only manufacturer's literature is not acceptable.
   b. Detailed chemical and gradation analysis for each proposed abrasive material.
2. Samples:
   a. Proposed Abrasive Materials: Minimum 5-pound sample for each type.

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b. Reference Panel:
   1) Surface Preparation:
      a) Prior to start of surface preparation, furnish a 4-inch by 4-inch steel panel for each grade of sandblast specified herein, prepared to specified requirements.
      b) Provide panel representative of the steel used; prevent deterioration of surface quality.
      c) Panel to be reference source for inspection upon approval by Engineer.
   2) Paint:
      a) Unless otherwise specified, before painting work is started, prepare minimum 8-inch by 10-inch sample with type of paint and application specified on similar substrate to which paint is to be applied.
      b) Furnish additional samples as required until colors, finishes, and textures are approved, including piping colors.
      c) Approved samples to be the quality standard for final finishes.

B. Informational Submittals:

1. Applicator's Qualification: List of references substantiating experience.
2. Coating manufacturer's Certificate of Compliance, in accordance with Section 01 43 33, Manufacturers' Field Services.
3. Factory Applied Coatings: Manufacturer's certification stating factory applied coating system meets or exceeds requirements specified.
4. Manufacturer's written verification that submitted material is suitable for the intended use.
5. Coating for Faying Surfaces: Manufacturer's test results that show the proposed coating meets the slip resistance requirements of the AISC Specification for Structural Joints using ASTM A325 or ASTM A490 bolts.
6. If the manufacturer of finish coating differs from that of shop primer, provide finish coating manufacturer's written confirmation that materials are compatible.
7. Manufacturer's written instructions and special details for applying each type of paint.

1.04 QUALITY ASSURANCE

A. Applicator Qualifications: Minimum 5 years' experience in application of specified products.

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B. Regulatory Requirements:

1. Meet federal, state, and local requirements limiting the emission of volatile organic compounds.
2. Perform surface preparation and painting in accordance with recommendations of the following:
   a. Paint manufacturer's instructions.
   b. SSPC PA 10.
   c. Federal, state, and local agencies having jurisdiction.

C. Mockup:

1. Before proceeding with Work under this section, finish one complete space or item of each color scheme required showing selected colors, finish texture, materials, quality of work, and special details.
2. After Engineer approval, sample spaces or items shall serve as a standard for similar work throughout the Project.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Shipping:

1. Where precoated items are to be shipped to the Site, protect coating from damage. Batten coated items to prevent abrasion.
2. Protect shop painted surfaces during shipment and handling by suitable provisions including padding, blocking, and use of canvas or nylon slings.

B. Storage:

1. Store products in a protected area that is heated or cooled to maintain temperatures within the range recommended by paint manufacturer.
2. Primed surfaces shall not be exposed to weather for more than 2 months before being topcoated, or less time if recommended by coating manufacturer.

1.06 PROJECT CONDITIONS

A. Environmental Requirements:

1. Do not apply paint in temperatures or moisture conditions outside of manufacturer's recommended maximum or minimum allowable.
2. Do not perform final abrasive blast cleaning whenever relative humidity exceeds 85 percent, or whenever surface temperature is less than 5 degrees F above dew point of ambient air.

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PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Nationally recognized manufacturers of paints and protective coatings who are regularly engaged in the production of such materials for essentially identical service conditions.

B. Minimum of 5 years' verifiable experience in manufacture of specified product.

C. Each of the following manufacturers is capable of supplying most of the products specified herein:

1. Sherwin Williams.
2. Carboline.
3. Tnemec.
4. PPG.
5. International.

2.02 ABRASIVE MATERIALS

A. Select abrasive type and size to produce surface profile that meets coating manufacturer's recommendations for specific primer and coating system to be applied.

2.03 PAINT MATERIALS

A. General:

1. Manufacturer's highest quality products suitable for intended service.
2. Compatibility: Only compatible materials from a single manufacturer shall be used in the Work. Particular attention shall be directed to compatibility of primers and finish coats.
3. Thinners, Cleaners, Driers, and Other Additives: As recommended by coating manufacturer.

B. Products:

Product	Definition
Acrylic Latex	Single-component, finish as required
Acrylic Sealer	Clear acrylic
Alkyd (Semigloss)	Semigloss alkyd
Alkyd Enamel	Optimum quality, gloss or semigloss finish as required, medium long oil

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Product	Definition
Bituminous Paint	Single-component, coal-tar pitch based
Block Filler	Primer-sealer designed for rough masonry surfaces, 100% acrylic emulsion
Coal-Tar Epoxy	Amine, polyamide, or phenolic epoxy type 70% volume solids minimum, suitable for immersion service
DTM Acrylic Primer	Surface tolerant, direct-to-metal water borne acrylic primer
DTM Acrylic Finish	Surface tolerant, direct-to-metal water borne acrylic finish coat
Elastomeric Polyurethane	100% solids, plural component, spray applied, high build, elastomeric polyurethane coating, suitable for the intended service
Epoxy Filler/Surfacer	100% solids epoxy trowel grade filler and surfacer, nonshrinking, suitable for application to concrete and masonry. Approved for potable water contact and conforming to NSF 61, where required
Epoxy Nonskid (Aggregated)	Polyamidoamine or amine converted epoxies aggregated; aggregate may be packaged separately
Epoxy Primer—Ferrous Metal	Anticorrosive, converted epoxy primer containing rust-inhibitive pigments
Epoxy Primer—Other	Epoxy primer, high-build, as recommended by coating manufacturer for specific galvanized metal, copper, or nonferrous metal alloy to be coated
Fusion Bonded Coating	100% solids, thermosetting, fusion bonded, dry powder epoxy, suitable for the intended service
NSF High Solids Epoxy	High solids amine epoxy, greater than 95% solids, capable of at least 20 mils thickness applied in a single coat.
High Build Epoxy	Polyamidoamine epoxy, minimum 69% volume solids, capability of 4 to 8 MDFT per coat
Inorganic Zinc Primer	Solvent or water based, having 85% metallic zinc content in the dry film; follow manufacturer's recommendation for topcoating

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Product	Definition
Latex Primer Sealer	Waterborne vinyl acrylic primer/sealer for interior gypsum board and plaster. Capable of providing uniform seal and suitable for use with specified finish coats
NSF Epoxy	Polyamidoamine epoxy, approved for potable water contact and conforming to NSF 61
Epoxy, High Solids	Polyamidoamine epoxy, 80% volume solids, minimum, suitable for immersion service
Polyurethane Enamel	Two-component, aliphatic or acrylic based polyurethane; high gloss finish
Organic Zinc Rich Primer	Epoxy or moisture cured urethane with 85-percent zinc content in the dry film, meeting the requirements of RCSC Specification for Structural Joints using High Strength Bolts, Class A or Class B, as required.
Rust-Inhibitive Primer	Single-package steel primers with anticorrosive pigment loading
Siloxane Sealer	Penetrating, water base, Siloxane Sealer specifically for water-proofing concrete surfaces, Clear matte finish.
Water Base Epoxy	Two-component, polyamide epoxy emulsion, finish as required

2.04 MIXING

A. Multiple-Component Coatings:

1. Prepare using each component as packaged by paint manufacturer.
2. No partial batches will be permitted.
3. Do not use multiple-component coatings that have been mixed beyond their pot life.
4. Furnish small quantity kits for touchup painting and for painting other small areas.
5. Mix only components specified and furnished by paint manufacturer.
6. Do not intermix additional components for reasons of color or otherwise, even within the same generic type of coating.

B. Colors: Formulate paints with colorants free of lead, lead compounds, or other materials that might be affected by presence of hydrogen sulfide or other gas likely to be present at Site.

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2.05 SHOP FINISHES

A. Shop Blast Cleaning: Reference Paragraph, Shop Coating Requirements.

B. Surface Preparation: Provide Engineer minimum 7 days' advance notice to start of shop surface preparation work and coating application work.

C. Shop Coating Requirements:

1. When required by equipment specifications, such equipment shall be primed and finish coated in shop by manufacturer and touched up in field with identical material after installation.
2. Where manufacturer's standard coating is not suitable for intended service condition, Engineer may approve use of a tie-coat to be used between manufacturer's standard coating and specified field finish. In such cases, tie-coat shall be surface tolerant epoxy as recommended by manufacturer of specified field finish coat. Coordinate details of equipment manufacturer's standard coating with field coating manufacturer.

D. Pipe:

1. Ductile Iron Pipe:
   a. Use SSPC standards as a guide for desired prepared surface. Follow recommendations of pipe and coating manufacturers for means and methods to achieve SSPC-equivalent surface.
   b. The surface preparation and application of the primer shall be performed by pipe manufacturer. Finish coats shall be performed by contractor in the field.
   c. For high performance (epoxy) coatings, follow additional recommendations of pipe and coating manufacturers.
   d. Prior to blast cleaning, grind smooth surface imperfections, including, but not limited to delaminating metal or oxide layers.
2. Steel Pipe:
   a. Surface preparation and application of primer shall be performed by pipe manufacturer. Finish coats shall be performed by contractor in the field.
   b. For pipe with epoxy lining, do not place end cap seals until pipe lining material has sufficiently dried.

PART 3 EXECUTION

3.01 GENERAL

A. Provide Engineer minimum 7 days' advance notice to start of field surface preparation work and coating application work.

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B. Perform the Work only in presence of Engineer, unless Engineer grants prior approval to perform the Work in Engineer's absence.

C. Schedule inspection of cleaned surfaces and all coats prior to succeeding coat in advance with Engineer.

3.02 EXAMINATION

A. Factory Finished Items:

1. Schedule inspection with Engineer before repairing damaged factory-finished items delivered to Site.
2. Repair abraded or otherwise damaged areas on factory-finished items as recommended by coating manufacturer. Carefully blend repaired areas into original finish. If required to match colors, provide full finish coat in field.

B. Surface Preparation Verification: Inspect and provide substrate surfaces prepared in accordance with these Specifications and printed directions and recommendations of paint manufacturer whose product is to be applied. The more stringent requirements shall apply.

3.03 PROTECTION OF ITEMS NOT TO BE PAINTED

A. Remove, mask, or otherwise protect hardware, lighting fixtures, switchplates, aluminum surfaces, machined surfaces, couplings, shafts, bearings, nameplates on machinery, and other surfaces not specified elsewhere to be painted.

B. Provide drop cloths to prevent paint materials from falling on or marring adjacent surfaces.

C. Protect working parts of mechanical and electrical equipment from damage during surface preparation and painting process.

D. Mask openings in motors to prevent paint and other materials from entering.

E. Protect surfaces adjacent to or downwind of Work area from overspray.

3.04 SURFACE PREPARATION

A. Field Abrasive Blasting:

1. Perform blasting for items and equipment where specified and as required to restore damaged surfaces previously shop or field blasted and primed or coated.
2. Refer to coating systems for degree of abrasive blasting required.

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3. Where the specified degree of surface preparation differs from manufacturer's recommendations, the more stringent shall apply.

B. Surface Contamination Testing:

1. A surface contamination analysis test shall be performed every **[A: 500] [B:]** square feet by means of a **[C: Chlor Test CSN Salts] [D:] [E: or approved equivalent]**.
2. Surface with chloride levels exceeding 3 µg/square centimeter for submerged surfaces and 5 µg/square centimeter for exposed surfaces shall be treated with a liquid soluble salt remover equivalent to CHLOR*RID (CHLOR*RID International, Chandler, AZ).
3. Follow manufacturer's recommendations and procedures for the use of this product to remove the surface contamination.

C. Metal Surface Preparation:

1. Where indicated, meet requirements of SSPC Specifications summarized below:
   a. SP 1, Solvent Cleaning: Removal of visible oil, grease, soil, drawing and cutting compounds, and other soluble contaminants by cleaning with solvent.
   b. SP 2, Hand Tool Cleaning: Removal of loose rust, loose mill scale, loose paint, and other loose detrimental foreign matter, using nonpower hand tools.
   c. SP 3, Power Tool Cleaning: Removal of loose rust, loose mill scale, loose paint, and other loose detrimental foreign matter, using power-assisted hand tools.
   d. SP 5, White Metal Blast Cleaning: Removal of visible oil, grease, dust, dirt, mill scale, rust, coatings, oxides, corrosion products, and other foreign matter by blast cleaning.
   e. SP 6, Commercial Blast Cleaning: Removal of visible oil, grease, dust, dirt, mill scale, rust, coatings, oxides, corrosion products, and other foreign matter, except for random staining limited to no more than 33 percent of each unit area of surface which may consist of light shadows, slight streaks, or minor discolorations caused by stains of rust, stains of mill scale, or stains of previously applied coatings.
   f. SP 7, Brush-Off Blast Cleaning: Removal of visible rust, oil, grease, soil, dust, loose mill scale, loose rust, and loose coatings. Tightly adherent mill scale, rust, and coating may remain on surface.
   g. SP 10, Near-White Blast Cleaning: Removal of visible oil, grease, dust, dirt, mill scale, rust, coatings, oxides, corrosion products, and other foreign matter, except for random staining limited to no more than 5 percent of each unit area of surface which may

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consist of light shadows, slight streaks, or minor discolorations caused by stains of rust, stains of mill scale, or stains of previously applied coatings.

h. SP 11, Power Tool Cleaning to Bare Metal: Removal of visible oil, grease, dirt, dust, mill scale, rust, paint, oxide, corrosion products, and other foreign matter using power-assisted hand tools capable of producing suitable surface profile. Slight residues of rust and paint may be left in lower portion of pits if original surface is pitted.

i. SP-16, Brush Blasting of Non-Ferrous Metals: A brush-off blast cleaned non-ferrous metal surface, when viewed without magnification, shall be free of all visible oil, grease, dirt, dust, metal oxides (corrosion products), and other foreign matter. Intact, tightly adherent coating is permitted to remain. A coating is considered tightly adherent if it cannot be removed by lifting with a dull putty knife. Bare metal substrates shall have a minimum profile of 19 micrometers (0.75 mil).

2. The words “solvent cleaning”, “hand tool cleaning”, “wire brushing”, and “blast cleaning”, or similar words of equal intent in these Specifications or in paint manufacturer’s specification refer to the applicable SSPC Specification.
3. Where OSHA or EPA regulations preclude standard abrasive blast cleaning, wet or vacu-blast methods may be required. Coating manufacturers’ recommendations for wet blast additives and first coat application shall apply.
4. Ductile Iron Pipe Supplied with Asphaltic Varnish Finish: Remove asphaltic varnish finish prior to performing specified surface preparation.
5. Hand tool clean areas that cannot be cleaned by power tool cleaning.
6. Round or chamfer sharp edges and grind smooth burrs, jagged edges, and surface defects.
7. Welds and Adjacent Areas:
   a. Prepare such that there is:
      1) No undercutting or reverse ridges on weld bead.
      2) No weld spatter on or adjacent to weld or any area to be painted.
      3) No sharp peaks or ridges along weld bead.
   b. Grind embedded pieces of electrode or wire flush with adjacent surface of weld bead.
8. Preblast Cleaning Requirements:
   a. Remove oil, grease, welding fluxes, and other surface contaminants prior to blast cleaning.
   b. Cleaning Methods: Steam, open flame, hot water, or cold water with appropriate detergent additives followed with clean water rinsing.

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c. Clean small isolated areas as above or solvent clean with suitable solvent and clean cloth.

9. Blast Cleaning Requirements:
   a. Type of Equipment and Speed of Travel: Design to obtain specified degree of cleanliness. Minimum surface preparation is as specified herein and takes precedence over coating manufacturer's recommendations.
   b. Select type and size of abrasive to produce surface profile that meets coating manufacturer's recommendations for particular primer to be used.
   c. Use only dry blast cleaning methods.
   d. Do not reuse abrasive, except for designed recyclable systems.
   e. Meet applicable federal, state, and local air pollution and environmental control regulations for blast cleaning, confined space entry (if required), and disposition of spent aggregate and debris.
10. Post-Blast Cleaning and Other Cleaning Requirements:
   a. Clean surfaces of dust and residual particles from cleaning operations by dry (no oil or water vapor) air blast cleaning or other method prior to painting. Vacuum clean enclosed areas and other areas where dust settling is a problem and wipe with a tack cloth.
   b. Paint surfaces the same day they are blasted. Reblast surfaces that have started to rust before they are painted.

D. Galvanized Metal, Copper, and Nonferrous Metal Alloy Surface Preparation:

1. Remove soil, cement spatter, and other surface dirt with appropriate hand or power tools.
2. Brush blast in accordance with SSPC SP 16.
3. Obtain and follow coating manufacturer's recommendations for additional preparation that may be required.

E. Concrete Surface Preparation:

1. Do not begin until 30 days after concrete has been placed.
2. Meet requirements of SSPC SP 13.
3. Remove grease, oil, dirt, salts or other chemicals, loose materials, or other foreign matter by solvent, detergent, or other suitable cleaning methods.
4. Brush-off blast clean to remove loose concrete and laitance, and provide a tooth for binding. Upon approval by Engineer, surface may be cleaned by acid etching method. Approval is subject to producing desired profile equivalent to No. 80 grit flint sandpaper. Acid etching of vertical or overhead surfaces shall not be allowed.

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5. Secure coating manufacturer's recommendations for additional preparation, if required, for excessive bug holes exposed after blasting.
6. Unless otherwise required for proper adhesion, ensure surfaces are dry prior to painting.

F. Plastic and FRP Surface Preparation:

1. Hand sand plastic surfaces to be coated with medium grit sandpaper to provide tooth for coating system.
2. Large areas may be power sanded or brush-off blasted, provided sufficient controls are employed so surface is roughened without removing excess material.

G. Masonry Surface Preparation:

1. Complete and cure masonry construction for 14 days or more before starting surface preparation work.
2. Remove oil, grease, dirt, salts or other chemicals, loose materials, or other foreign matter by solvent, detergent washing, or other suitable cleaning methods.
3. Clean masonry surfaces of mortar and grout spillage and other surface deposits using one of the following:
    a. Nonmetallic fiber brushes and commercial muriatic acid followed by rinsing with clean water.
    b. Brush-off blasting.
    c. Water blasting.
4. Do not damage masonry mortar joints or adjacent surfaces.
5. Leave surfaces clean and, unless otherwise required for proper adhesion, dry prior to painting.
6. Masonry Surfaces to be Painted: Uniform texture and free of surface imperfections that would impair intended finished appearance.
7. Masonry Surfaces to be Clear Coated: Free of discolorations and uniform in texture after cleaning.

H. Wood Surface Preparation:

1. Replace damaged wood surfaces or repair in a manner acceptable to Engineer prior to start of surface preparation.
2. Solvent clean (mineral spirits) knots and other resinous areas and coat with shellac or other knot sealer, prior to painting. Remove pitch by scraping and wipe clean with mineral spirits or turpentine prior to applying knot sealer.
3. Round sharp edges by light sanding prior to priming.
4. Filler:
    a. Synthetic-based wood putty approved by paint manufacturer for paint system.

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b. For natural finishes, color of wood putty shall match color of finished wood.
c. Fill holes, cracks, and other surface irregularities flush with surrounding surface and sand smooth.
d. Apply putty before or after prime coat, depending on compatibility and putty manufacturer's recommendations.
e. Use cellulose type putty for stained wood surfaces.

5. Ensure surfaces are clean and dry prior to painting.

I. Gypsum Board Surface Preparation: Typically, new gypsum board surfaces need no special preparation before painting.

1. Surface Finish: Dry, free of dust, dirt, powdery residue, grease, oil, or any other contaminants.

J. Existing Painted Surfaces to be Repainted Surface Preparation:

1. Detergent wash and freshwater rinse.
2. Clean loose, abraded, or damaged coatings to substrate by hand or power tool, SP 2 or SP 3.
3. Feather surrounding intact coating.
4. Apply one spot coat of specified primer to bare areas, overlapping prepared existing coating.
5. Apply one full finish coat of specified primer to entire surface.
6. If an aged, plural-component material is to be topcoated, contact coating manufacturer for additional surface preparation requirements.
7. Application of Cosmetic Coat:
   a. It is assumed that existing coatings have oxidized sufficiently to prevent lifting or peeling when overcoated with paints specified.
   b. Check compatibility by application to a small area prior to starting painting.
   c. If lifting or other problems occur, request disposition from Engineer.
8. Perform blasting as required to restore damaged surfaces. Materials, equipment, procedures shall meet requirements of SSPC.

3.05 SURFACE CLEANING

A. Brush-off Blast Cleaning:

1. Equipment, procedure, and degree of cleaning shall meet requirements of SSPC SP 7.
2. Abrasive: Either wet or dry blasting sand, grit, or nutshell.
3. Select various surface preparation parameters, such as size and hardness of abrasive, nozzle size, air pressure, and nozzle distance from surface such that surface is cleaned without pitting, chipping, or other damage.

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4. Verify parameter selection by blast cleaning a trial area that will not be exposed to view.
5. Engineer will review acceptable trial blast cleaned area and use area as a representative sample of surface preparation.
6. Repair or replace surface damaged by blast cleaning.

B. Acid Etching:

1. After precleaning, spread the following solution by brush or plastic sprinkling can: One part commercial muriatic acid reduced by two parts water by volume. Adding acid to water in these proportions gives an approximate 10 percent solution of HCl.
2. Application:
   a. Rate: Approximately 2 gallons per 100 square feet.
   b. Work acid solution into surface by hard-bristled brushes or brooms until complete wetting and coverage is obtained.
   c. Acid will react vigorously for a few minutes, during which time brushing shall be continued.
   d. After bubbling subsides (10 minutes), hose down remaining slurry with high pressure clean water.
   e. Rinse immediately to avoid formation on the surface of salts that are difficult to remove.
   f. Thoroughly rinse to remove any residual acid surface condition that may impair adhesion.
3. Ensure surface is completely dry before application of coating.
4. Apply acid etching to obtain a “grit sandpaper” surface profile. If not, repeat treatment.

C. Solvent Cleaning:

1. Consists of removal of foreign matter such as oil, grease, soil, drawing and cutting compounds, and any other surface contaminants by using solvents, emulsions, cleaning compounds, steam cleaning, or similar materials and methods that involve a solvent or cleaning action.
2. Meet requirements of SSPC SP 1.

3.06 APPLICATION

A. General:

1. The intention of these Specifications is for new, interior and exterior masonry, concrete, and metal, and submerged metal surfaces to be painted, whether specifically mentioned or not, except as specified otherwise. Do not paint exterior concrete surfaces, unless specifically indicated.
2. Extent of Coating (Immersion): Coatings shall be applied to internal vessel and pipe surfaces, nozzle bores, flange gasket sealing surfaces,

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carbon steel internals, and stainless steel internals, unless otherwise specified. All immersion service coating systems shall receive an intermediate stripe coat on all edges, corners, welds and irregular surfaces.

3. For coatings subject to immersion, obtain full cure for completed system. Consult coatings manufacturer's written instructions for these requirements. Do not immerse coating until completion of curing cycle.
4. Apply coatings in accordance with these Specifications and paint manufacturers' printed recommendations and special details. The more stringent requirements shall apply. Allow sufficient time between coats to assure thorough drying of previously applied paint.
5. Sand wood lightly between coats to achieve required finish.
6. Vacuum clean surfaces free of loose particles. Use tack cloth just prior to applying next coat.
7. Fusion Bonded Coatings Method Application: Electrostatic, fluidized bed, or flocking.
8. Coat units or surfaces to be bolted together or joined closely to structures or to one another prior to assembly or installation.
9. Water-Resistant Gypsum Board: Use only solvent type paints and coatings.
10. On pipelines, terminate coatings along pipe runs to 1 inch inside pipe penetrations.
11. Keep paint materials sealed when not in use.
12. Where more than one coat is applied within a given system, alternate colors to provide a visual reference showing required number of coats have been applied.

B. Galvanized Metal, Copper, and Nonferrous Metal Alloys:

1. Concealed galvanized, copper, and nonferrous metal alloy surfaces (behind building panels or walls) do not require painting, unless specifically indicated herein.
2. Exposed galvanized surfaces including galvanized steel framing and galvanized steel electrical conduit do not require painting unless specifically noted or as shown in the architectural schedules on the Drawings.
3. Where indicated to be painted, prepare surface and apply primer in accordance with System No. 10 specification. Apply intermediate and finish coats of the coating system appropriate for the exposure.

C. Porous Surfaces, Such As Concrete and Masonry:

1. Filler/Surfacer: Use coating manufacturer's recommended product to fill air holes, bug holes, and other surface voids or defects.

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2. Prime Coat: May be thinned to provide maximum penetration and adhesion.
    a. Type and Amount of Thinning: Determined by paint manufacturer and dependent on surface density and type of coating.
3. Surface Specified to Receive Water Base Coating: Damp, but free of running water, just prior to application of coating.

D. Film Thickness and Coverage:

1. Number of Coats:
    a. Minimum required without regard to coating thickness.
    b. Additional coats may be required to obtain minimum required paint thickness, depending on method of application, differences in manufacturers' products, and atmospheric conditions.
2. Application Thickness:
    a. Do not exceed coating manufacturer's recommendations.
    b. Measure using a wet film thickness gauge to ensure proper coating thickness during application.
3. Film Thickness Measurements and Electrical Inspection of Coated Surfaces:
    a. Perform with properly calibrated instruments.
    b. Recoat and repair as necessary for compliance with specification.
    c. Coats are subject to inspection by Engineer and coating manufacturer's representative.
4. Visually inspect concrete, masonry, nonferrous metal, plastic, and wood surfaces to ensure proper and complete coverage has been attained.
5. Give particular attention to edges, angles, flanges, and other similar areas, where insufficient film thicknesses are likely to be present, and ensure proper millage in these areas.
6. Apply additional coats as required to achieve complete hiding of underlying coats. Hiding shall be so complete that additional coats would not increase the hiding.

3.07 PROTECTIVE COATINGS SYSTEMS AND APPLICATION SCHEDULE

A. Unless otherwise shown or specified, paint surfaces in accordance with the following application schedule. In the event of discrepancies or omissions in the following, request clarification from Engineer before starting work in question.

B. Additional painting requirements are shown on Drawings and in the Piping Schedule.

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C. System No. 1 Submerged Metal—Potable Water:

Surface Prep.	Paint Material	Min. Coats, Cover
SP 5, White Metal Blast Cleaning	NSF Epoxy	3 coats, 3 MDFTPC (Note 2) Stripe coat, between second and third coats, all edges, welds, and irregular surfaces.

1. Use on the following items or areas:
   a. Metal surfaces, new, below a plane 1 foot above the maximum liquid surface; metal surfaces above the maximum liquid surface that are a part of the immersed equipment; surfaces of metallic items, such as wall pipes, pipes, pipe sleeves, access manholes, gate guides and thimbles, and structural steel that are embedded in concrete; and the following specific surfaces:
      1) Interior surfaces of steel piping noted in the Piping Schedule.
      2) Exterior surfaces of immersed pipe.
      3) Interior surfaces of pumps.
      4) Immersed portions of vertical turbine pumps.
2. Each coat shall be tinted different colors for visual verification of coverage.

D. System No. 4 Exposed Metal—Highly Corrosive:

Surface Prep.	Paint Material	Min. Coats, Cover
SP 10, Near-White Blast Cleaning	Epoxy Primer—Ferrous Metal	1 coat, 2.5 MDFT
	High Build Epoxy	1 coat, 4 MDFT
	Polyurethane Enamel	1 coat, 3 MDFT

1. Use on the following items or areas:
   a. Exposed metal surfaces, new and located inside or outside of structures and exposed to weather and the following specific surfaces:
      1) Bare steel structural framing for buildings and equipment.
      2) Exposed bare ferrous metal inside chemical storage building.

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E. System No. 5 Exposed Metal—Mildly Corrosive:

Surface Prep.	Paint Material	Min. Coats, Cover
SP 10, Near-White Blast Cleaning	Epoxy Primer—Ferrous Metal	1 coat, 2.5 MDFT
	Polyurethane Enamel	1 coat, 3 MDFT

1. Use on the following items or areas:
    a. Exposed metal surfaces, new and located inside or outside of structures and exposed to weather or in a highly humid atmosphere, such as pipe galleries and similar areas, and the following specific surfaces:
        1) Exposed piping.
        2) Valve operators and motors.
        3) Gate operators.
        4) Hollow metal doors and frames.
        5) All bare ferrous metal without a specified coating system.
        6) Where shown in the architectural schedules on the Drawings.

F. System No. 7 Concrete Encased Metal:

Surface Prep.	Paint Material	Min. Coats, Cover
SP 6, Commercial Blast Cleaning	High Build Epoxy	2 coats, 16 MDFT

1. Use on the following items or areas:
    a. Use on concrete encased ferrous metals including wall pipes, pipe sleeves, access manholes, gate guides, and thimbles; and the following specific surfaces:
        1) TBD.

G. System No. 8 Buried Metal—General:

Surface Prep.	Paint Material	Min. Coats, Cover
SP 10, Near-White Blast Cleaning	High Build Epoxy	2 coats, 16 MDFT

1. For steel pipe and fittings, follow AWWA C209 and AWWA C214.
2. Use on the following items or areas:
    a. Buried, belowgrade portions of steel items, except buried stainless steel or ductile iron and the following specific surfaces:
        1) TBD.

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H. System No. 10 Galvanized Metal, Copper, and Nonferrous Metal Alloy Conditioning:

Surface Prep.	Paint Material	Min. Coats, Cover
In accordance with Paragraph Galvanized Metal, Copper, and Nonferrous Metal Alloy Surface Preparation	Epoxy Primer—Other	As recommended by coating manufacturer Remaining coats as required for exposure

1. Use on the following items or areas:
   a. Galvanized surfaces requiring painting and the following specific surfaces:
      1) TBD.
   b. After application of System No. 10, apply finish coats as required for exposure.

I. System No. 11 Faying Surfaces of Slip Critical Bolted Connections:

Surface Prep.	Paint Material	Min. Coats, Cover
SP 10, Near-White Blast Cleaning	Organic Zinc Rich Primer	1 coat, 3 MDFT

1. Use on faying surfaces of slip critical joints as specified and as shown on Drawings.
2. Provide primer in accordance with RCSC Specification for Structural Joints using High-Strength Bolts.

J. System No. 18 Concrete Tank Lining—Potable Water:

Surface Prep.	Paint Material	Min. Coats, Cover
In accordance with Paragraph Concrete Surface Preparation	Epoxy Filler/Surfacer (NSF-approved)	As required to fill voids and level surface
	NSF 100 Percent Solids Epoxy	2 coats at 20 mils per coat, 40 mils MDFT

1. Use on the following items or areas:
   a. Concrete surfaces below a plane 1 foot above maximum liquid surface the following specific surfaces:
      1) Flocculation Basin.
      2) Sedimentation Basin.
      3) Filter Basin.

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K. System No. 21 Skid-Resistant—Concrete:

Surface Prep.	Paint Material	Min. Coats, Cover
In accordance with Paragraph Concrete Surface Preparation	Epoxy Nonskid (Aggregated)	1 coat, 160 SFPG

1. Use on the following items or areas:
   a. Where shown in the architectural schedules on the Drawings.

L. System No. 25 Exposed FRP, PVC:

Surface Prep.	Paint Material	Min. Coats, Cover
In accordance with Paragraph Plastic and FRP Surface Preparation	Acrylic Latex Semigloss	2 coats, 320 SFPGPC

1. Use on the following items or areas:
   a. All exposed-to-view PVC and CPVC surfaces, and FRP surfaces without integral UV-resistant gel coat.
   b. TBD

M. System No. 27 Aluminum and Dissimilar Metal Insulation:

Surface Prep.	Paint Material	Min. Coats, Cover
Solvent Clean (SP 1)	Prime in accordance with manufacturer's recommendations	
	Bituminous Paint	1 coat, 10 MDFT

1. Use on aluminum surfaces embedded or in contact with concrete and the following items or areas:
   a. As directed in these technical specifications.

N. System No. 29A Fusion Bonded, Steel Dowel Coating:

Surface Prep.	Paint Material	Min. Coats, Cover
SP 10, Near-White Blast Cleaning	Fusion Bonded Coating 100% Solids Epoxy	1 or 2 coats, 7 MDFT

1. Use on steel expansion joint dowels as specified in Section 03 15 00, Concrete Joints and Accessories.

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O. System No. 30 Tape Coat System for Pipe and Pipe Appurtenances:

1. Petroleum Wax Tape: For buried valves, flanges, restrained joints and couplings.
    a. Comply with AWWA C217.
    b. Minimum 60-mil tape, 50 percent overlap.
    c. Manufacturer and Product:
        1) Tapecoat; Envirotape (Below Grade); Color Coat (Above Grade).
        2) Or equal.
2. Cold Applied Elastomeric Tape: For copper pipe.
    a. For steel fittings and pipe, follow AWWA C209 and AWWA C214.
    b. Straight Pipe Runs:
        1) Minimum 50-mil tape, 50 percent overlap, 2-inch width.
        2) Holiday free.
        3) Manufacturer and Product:
            a) Tapecoat M50.
            b) Or equal.
    c. Elbows and Tees:
        1) Minimum 50 mil tape, 50 percent overlap, 2-inch width, 1000 percent elongation.
        2) Holiday free.
        3) Manufacturer and Product:
            a) Tapecoat T-Tape.
            b) Or equal.

3.08 ARCHITECTURAL PAINT SYSTEMS AND APPLICATION SCHEDULE

A. Unless otherwise shown or specified, paint surfaces in accordance with the following application schedule. In the event of discrepancies or omissions in the following, request clarification from Engineer before starting work in question.

B. As shown in the architectural schedules on Drawings. Additional requirements are included in the Piping Schedule.

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C. System No. 106 Galvanized Metal:

Surface Prep.	Paint Material	Min. Coats, Cover
In accordance with Paragraph Galvanized Metal, Copper, and Nonferrous Metal Alloy Surface Preparation	Manufacturer's Recommended Primer	1 coat, as recommended by manufacturer
	Alkyd Enamel (Semigloss)	2 coats, 4 MDFT

1. Use on the following items or areas:
   a. Where shown in the architectural schedules on Drawings.

D. System No. 109 Masonry, Semigloss:

Surface Prep.	Paint Material	Min. Coats, Cover
In accordance with Paragraph Masonry Surface Preparation	Block Filler	1 coat, 75 SFPG
	Acrylic Latex (Semigloss)	2 coats, 240 SFPGPC

1. Use on the following items or areas:
   a. Where shown in the architectural schedules on Drawings.

E. System No. 110 Concrete Sealer:

Surface Prep.	Paint Material	Min. Coats, Cover
In accordance with Paragraph Concrete Surface Preparation	Siloxane Sealer	2 flood coats or as recommended by sealer manufacturer.

1. Use on the following items or areas:
   a. Where shown in the architectural schedules on the Drawings.

F. System No. 115 Gypsum Board and Plaster, Semigloss :

Surface Prep.	Paint Material	Min. Coats, Cover
In accordance with Paragraph Gypsum Board Surface Preparation	Latex Primer/Sealer	1 coat, 350 SFPG

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Surface Prep.	Paint Material	Min. Coats, Cover
	Acrylic Latex (Semigloss) or Alkyd (Semigloss)	2 coats, 400 SFPGPC

1. Use on the following items or areas:
    a. Where shown in the architectural schedules on the Drawings.

G. System No. 116 Gypsum Board and Plaster, Gloss Epoxy:

Surface Prep.	Paint Material	Min. Coats, Cover
In accordance with Paragraph Gypsum Board Surface Preparation	Manufacturer's Recommended Primer	1 coat, 350 SFPG
	Water Base Epoxy (Gloss)	1 coat, 250 SFPG

1. Use on the following items or areas:
    a. Where shown in the architectural schedules on the Drawings.

H. System No. 117 Concrete Masonry, Gloss Epoxy:

Surface Prep.	Paint Material	Min. Coats, Cover
In accordance with Paragraph Masonry Surface Preparation	Block Filler	1 coat, 75 SFPG
	Water Base Epoxy (Gloss)	2 coats, 300 SFPGPC

1. Use on the following items or areas:
    a. Where shown in the architectural schedules on the Drawings.

I. System No. 121 Concrete, Skid-Resistant:

Surface Prep.	Paint Material	Min. Coats, Cover
In accordance with Paragraph Concrete Surface Preparation	Epoxy Nonskid (Aggregated)	1 coat, 160 SFPG

1. Use on the following items or areas:
    a. Where shown in the architectural schedules on the Drawings.

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3.09 COLORS

A. Provide as shown in the architectural schedules on Drawings, and as shown in Piping Schedule. Request color selection by the Engineer if no color is shown.

B. Proprietary identification of colors is for identification only. Selected manufacturer may supply matches.

C. Equipment Colors:

1. Equipment includes the machinery or vessel itself plus the structural supports and fasteners and attached electrical conduits.
2. Paint equipment and piping one color as selected on Drawings.
3. Paint nonsubmerged portions of equipment the same color as the piping it serves, except as itemized below:
    a. Dangerous Parts of Equipment and Machinery: OSHA Orange.
    b. Fire Protection Equipment and Apparatus: OSHA Red.
    c. Radiation Hazards: OSHA Purple.
    d. Physical hazards in normal operating area and energy lockout devices, including, but not limited to, electrical disconnects for equipment and equipment isolation valves in air and liquid lines under pressure: OSHA Yellow.

D. Pipe Identification Painting:

1. Color code nonsubmerged metal piping, except electrical conduit. Paint fittings and valves the same color as pipe, except equipment isolation valves.
2. Pipe Color Coding: In accordance with Piping Schedule.
3. On exposed stainless steel piping, apply color 24 inches in length along pipe axis at connections to equipment, valves, or branch fittings, at wall boundaries, and at intervals along piping not greater than 9 feet on center.
4. Pipe Supports: Painted light gray, as approved by Engineer.
5. Fiberglass reinforced plastic (FRP) pipe, polyvinylidene fluoride (PVDF), and polyvinyl chloride (PVC) pipe located inside of buildings and enclosed structures will not require painting, except as noted or scheduled.
6. Galvanized electrical conduit shall not be painted unless noted otherwise in the Drawings.

3.10 FIELD QUALITY CONTROL

A. Testing Equipment:

1. Provide calibrated electronic type dry film thickness gauge to test coating thickness specified in mils.

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2. Provide low-voltage wet sponge electrical holiday detector to test completed coating systems, 20 mils dry film thickness or less, except zinc primer, high-build elastomeric coatings, and galvanizing, for pinholes, holidays, and discontinuities, as manufactured by Tinker and Rasor, San Gabriel, CA, Model M-1.
3. Provide high-voltage spark tester to test completed coating systems in excess of 20 mils dry film thickness. Unit as recommended by coating manufacturer.

B. Testing:

1. Thickness and Continuity Testing:
   a. Measure coating thickness specified in mils with a magnetic type, dry film thickness gauge, in accordance with SSPC PA 2. Check each coat for correct millage. Do not make measurement before a minimum of 8 hours after application of coating.
   b. Holiday detect coatings 20 mils thick or less, except zinc primer and galvanizing, with low voltage wet sponge electrical holiday detector in accordance with NACE SP0188.
   c. Holiday detect coatings in excess of 20 mils dry with high voltage spark tester as recommended by coating manufacturer and in accordance with NACE SP0188.
   d. After repaired and recoated areas have dried sufficiently, retest each repaired area. Final tests may also be conducted by Engineer.

C. Inspection: Leave staging and lighting in place until Engineer has inspected surface or coating. Replace staging removed prior to approval by Engineer. Provide additional staging and lighting as requested by Engineer.

D. Unsatisfactory Application:

1. If item has an improper finish color or insufficient film thickness, clean surface and topcoat with specified paint material to obtain specified color and coverage. Obtain specific surface preparation information from coating manufacturer.
2. Evidence of runs, bridges, shiners, laps, or other imperfections is cause for rejection.
3. Repair defects in accordance with written recommendations of coating manufacturer.

E. Damaged Coatings, Pinholes, and Holidays:

1. Hand or power sand visible areas of chipped, peeled, or abraded paint, and feather edges. Follow with primer and finish coat. Depending on extent of repair and appearance, a finish sanding and topcoat may be required.

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2. Remove rust and contaminants from metal surface. Provide surface cleanliness and profile in accordance with surface preparation requirements for specified paint system.
3. Feather edges and repair in accordance with recommendations of paint manufacturer.
4. Apply finish coats, including touchup and damage-repair coats in a manner that will present a uniform texture and color-matched appearance.

3.11 MANUFACTURER'S SERVICES

A. In accordance with Section 01 43 33, Manufacturers' Field Services, coating manufacturer's representative shall be present at Site as follows:

1. On first day of application of any coating system.
2. A minimum of **[A: two] [B:]** additional Site inspection visits, each for a minimum of 4 hours, in order to provide Manufacturer's Certificate of Proper Installation.
3. As required to resolve field problems attributable to or associated with manufacturer's product.
4. To verify full cure of coating prior to coated surfaces being placed into immersion service.

3.12 CLEANUP

A. Place cloths and waste that might constitute a fire hazard in closed metal containers or destroy at end of each day.

B. Upon completion of the Work, remove staging, scaffolding, and containers from Site or destroy in a legal manner.

C. Remove paint spots, oil, or stains upon adjacent surfaces and floors and leave entire job clean.

3.13 SUPPLEMENTS

A. The supplements listed below, following "End of Section," are a part of this specification:

1. Paint System Data Sheet (PSDS)
2. Product Data Sheet (PDS).

END OF SECTION

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PAINT SYSTEM DATA SHEET

Complete this PSDS for each coating system, include all components of the system (surface preparation, primer, intermediate coats, and finish coats). Include all components of a given coating system on a single PSDS.

Paint System Number (from Spec.):		
Paint System Title (from Spec.):		
Coating Supplier:		
Representative:		
Surface Preparation:		
Paint Material (Generic)	**Product Name/Number (Proprietary)**	**Min. Coats, Coverage**

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PAINT PRODUCT DATA SHEET

Complete and attach manufacturer's Technical Data Sheet to this PDS for each product submitted. Provide manufacturer's recommendations for the following parameters at temperature (F)/relative humidity:

Temperature/RH	50/50	70/30	90/25
Induction Time			
Pot Life			
Shelf Life			
Drying Time			
Curing Time			
Min. Recoat Time			
Max. Recoat Time			

Provide manufacturer's recommendations for the following:

Mixing Ratio:

Maximum Permissible Thinning:_____

Ambient Temperature Limitations: min.: max.:_____

Surface Temperature Limitations: min.: max.:_____

Surface Profile Requirements: min.:_____ max.:_____

[A: Attach additional sheets detailing manufacturer's recommended storage requirements and holiday testing procedures.]

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SECTION 09 96 35
CHEMICAL-RESISTANT COATINGS

PART 1 GENERAL

1.01 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. List materials in proposed system.
   b. Manufacturer's product specification.
   c. Chemical resistance test results for exposure to service conditions.
   d. Application instructions.
   e. Configuration details of materials at terminations, construction joints, floor drains, and trenches.
2. Samples: 4-inch square complete system proposed for use showing thickness and finish.

B. Informational Submittals:

1. Letter from manufacturer stating applicator is qualified to do the Work and meets the quality assurance minimum experience requirements.
2. Sample of warranty, prior to starting the Work.
3. Installation instructions.
4. Field inspection and test reports.
5. Manufacturer's Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers' Field Services**.**
6. Special guarantee.

1.02 QUALITY ASSURANCE

A. Manufacturer's Experience: Minimum 5 years manufacturing proposed products.

B. Applicator's Experience: Minimum 3 years applying proposed products.

1.03 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials in manufacturer's original, unopened containers.

B. Storage: Maintain materials in clean and dry condition. Follow manufacturer's instructions.

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1.04 ENVIRONMENTAL REQUIREMENTS

A. Temperature: Apply coating only when substrate, ambient air, and coating material are 65 degrees F or above.

B. Substrate: Not wet or have standing water.

C. Ventilation: Provide during and after application to meet all applicable safety and health regulations.

1.05 EXTRA MATERIALS

A. Furnish minimum 2 gallons of unopened topcoating material for future use by Owner.

1.06 SPECIAL GUARANTEE

A. Furnish manufacturer's extended guarantee or warranty, with Owner named as beneficiary, in writing, as special guarantee. Special guarantee shall provide for correction, or at the option of the Owner, removal and replacement of Work specified in this Specification section found defective during a period of 2 years after the date of Substantial Completion. Duties and obligations for correction or removal and replacement of defective Work as specified in the General Conditions.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Sherwin Williams.
B. Carboline.
C. Tnemec.
D. PPG.
E. International.

2.02 SERVICE CONDITIONS

A. Location: Covered, ambient temperature conditions.

B. Surface: Concrete floors, walls, containment walls and vault for chemical storage and handling.

C. Traffic: Foot, light hand truck, forklifts.

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D. Chemicals Stored in Containment Areas:

1. Sulfuric acid, 93 percent solution.
2. Sodium Hydroxide, up to 50 percent solution.
3. Sodium Hypochlorite, 0.8 and 10 percent solutions.
4. at Hydrochloric acid solutions to 37 percent.
5. Anionic and cationic polymers, various concentrations.
6. Phosphoric acid, 50 to 85 percent solution.
7. Ferric Chloride, 40 percent solution.

2.03 COATING SYSTEMS

A. Chemical-Resistant Coatings: A mixture of liquid resin-based material, setting agent, and filler designed to be troweled into place to cure to a hard state.

B. Mat-Reinforced Vinyl Ester (System CRC-1): Primer, fiberglass mat, saturant, and two trowel-applied coats of vinyl ester resin with silica fillers. Finished system thickness 150 mils minimum.

C. Novolac Epoxy (System CRC-2): Primer and one trowel-applied coat of novolac epoxy resin with silica fillers. Finished system thickness 100 mils minimum.

D. All coating systems applied to floors shall receive a non-skid finish.

2.04 MIXING

A. Thoroughly mix until homogeneous following manufacturer's instructions.

B. Mix only components furnished by coating manufacturer.

PART 3 EXECUTION

3.01 EXAMINATION

A. Surface Preparation:

1. Inspect and provide substrate surfaces prepared in accordance with these Specifications and the printed directions and recommendations of the system manufacturer whose product is to be applied.
2. Provide Engineer minimum 3 days' advance notice of start of surface preparation and system application Work.
3. Perform Work only in presence of Engineer, unless Engineer grants prior approval to perform Work in Engineer's absence.

B. Schedule inspection with Engineer in advance for cleaned surfaces and system application Work.

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3.02 PREPARATION

A. In accordance with Section 09 90 00, Painting and Coating and the manufacturer's printed directions and recommendations.

B. Fill holes and cracks with manufacturer's recommended materials to produce even surface for application of systems.

C. Concrete Surfaces:

1. Do not begin until 30 days after concrete has been placed.
2. Remove grease, oil, dirt, salts or other chemicals, loose materials, or other foreign matter by solvent, detergent, or other suitable cleaning methods.
3. Brushoff blast clean to remove loose concrete and provide a tooth for binding. Upon approval by Engineer, surface may be acid etched with muriatic acid solution. Approval, subject to producing desired profile.
4. Secure coating manufacturer's recommendations for additional preparation if required for excessive bug holes exposed after blasting.
5. Unless otherwise required for proper adhesion, ensure surfaces are dry prior to painting.

3.03 APPLICATION

A. Install coating systems in accordance with manufacturer's printed instructions.

B. Install coating systems on vertical and horizontal surfaces, including caps, within containment wall for storage tanks, pumps, and piping.

C. Extend surfacing completely under structures and equipment located within the containment area. Install at construction joints in substrate and floor drains, trenches, and other components within the containment area.

3.04 FIELD QUALITY CONTROL

A. Inspection:

1. Inspect finished system for complete, uniform coverage of specified area. Evidence of defects include improper thickness, hardness, and appearance.
2. Engineer may require electrical spark test or other tests to be performed by Contractor when evidence of incomplete coverage exists.

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3.05 MANUFACTURER'S SERVICES

A. Provide manufacturer's representative at Site in accordance with Section 01 43 33, Manufacturers' Field Services, for installation assistance, inspection, and Manufacturer's Certificate of Proper Installation.

3.06 APPLICATION SCHEDULE

A. Unless otherwise shown or specified, apply coatings in accordance with the following application schedule. In the event of discrepancies or omissions in the following, request clarification from Engineer before starting Work in question.

B. Coating System CRC-1: Use in the following areas:

1. Phosphoric acid storage and pump area.

C. Coating System CRC-2: Use in the following areas:

1. Sulfuric acid storage and pump area.
2. Ferric chloride storage and pump area.
3. Sodium hypochlorite storage and pump area.
4. Sodium hydroxide storage and pump area.
5. Polymer storage and pump area.

3.07 COLOR

A. The ferric chloride storage area shall be tinted rust brown. Since the sulfuric acid is stored in the same containment area as the ferric chloride then it should be tinted the same color as the ferric chloride.

END OF SECTION

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CORROSION CONTROL ASSISTANCE FORM

TO: Corrosion Control Specialist. DATE:_____
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FROM: Name:_____ Title:_____

Address:_____

Project Description:_____

Project No.:_____

Area Requiring Specific Protection:_____

_____

Items to be Coated:_____

_____

Site Location:_____

SERVICE CONDITIONS
(Check Appropriate Items)

Immersion_____ Splash/Spillage_____ Chemical Fumes_____

Marine/Offshore_____ Industrial_____ Other_____

Chemicals Involved_____

New Construction_____ Existing Structure_____ Uncoated_____

Coated_____ Coated With (If Known)_____

Operating Temp. Range____ Ambient Conditions_____

Surface Preparation Possible: Abrasive Blast_____

Power Tool Cleaning_____ Other_____

Other Pertinent Data:_____

_____

Feedback Required By (Date):_____

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SECTION 10 14 00
SIGNAGE

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards that may be referenced in this section:

1. American Society of Mechanical Engineers (ASME): A13.1, Scheme for the Identification of Piping Systems.
2. ASTM International (ASTM):
   a. A53/A53M, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless.
   b. D709, Standard Specification for Laminated Thermosetting Materials.
3. The Chlorine Institute, Inc.: WC-1, Wall Chart: Handling Chlorine Cylinders and Ton Containers.
4. International Code Council (ICC):
   a. A117.1, Accessible and Usable Buildings and Facilities.
   b. International Fire Code (IFC): Chapter 27, Hazardous Materials-General Provisions.
5. National Fire Protection Association (NFPA):
   a. 704, Standard System for the Identification of the Hazards of Materials for Emergency Response.
   b. HAZ-01, Fire Protection Guide to Hazardous Materials.
6. Occupational Safety and Health Act (OSHA).
7. U.S. Department of Transportation, Federal Highway Administration: Manual on Uniform Traffic Control Devices for Streets and Highways.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Drawings showing layouts, actual letter sizes and styles, and Project-specific mounting details.
   b. Manufacturer's literature showing letter sizes and styles, sign materials, and standard mounting details.
2. **[A: Anchorage and bracing data sheets and drawings as required by Section 01 88 15, Anchorage and Bracing.]**
3. Samples: **[B: One full size for each type of nameplate, sign, and label specified.] [C:]**

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B. Informational Submittals:

1. Manufacturer's installation instructions.
2. **[A: Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.]**

PART 2 PRODUCTS

2.01 FACILITY ENTRANCE MARKER

A. **[A: Cast-in-Place] [B: Precast]** Concrete: As detailed on Drawings.

B. Molds for Message:

1. Furnish plastic letter, numeral, and symbol molds for insertion into formwork.
2. Form with tapered sides for release without spalling concrete.

2.02 **[A: FACILITY] [B: BUILDING]** NAME PLAQUE

A. Text Material: **[A: Cast bronze.] [B: Type stainless steel.] [C: Other.]**

B. Background Material: **[A:]**

C. Size: **[A: 18 inches by 27 inches] [B:]** and minimum 1/4 inch thick.

D. Lettering and Trim: Raised 1/8 inch, minimum.

E. Finish:

1. Border Face and Edge, and Lettering Face: Fine satin hand finish.
2. Background: Dark statuary bronze, finely pebbled surface.

F. Lettering and Border Outlines: Hand-tool, clean, and sharp.

G. Lettering Style: **[A: Condensed block.] [B:]**

H. Tablet Inscription Text: **[A: To be furnished by Owner or Engineer.] [B: As shown.] [C:]**

I. Fasteners: **[A: Stainless steel screws with rosettes.] [B: Concealed.]**

J. Manufacturer's name is allowed on backside.

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2.03 **[A: FACILITY] [B: BUILDING]** DIRECTORY

A. Modular System:

1. Material: Melamine thermoset plastic, rated self-extinguishing, meeting ASTM D709.
2. Thickness: 1/8 inch.
3. Mounting: 1/4-inch thick minimum backup panel.
4. Letters: **[A: White] [B:]** raised **[C: Helvetica] [D: condensed] [E: regular]** style upper **[F: and lower]** case.
5. Background: **[G: Brown.] [H:]**

B. Fasteners: **[A: Concealed mechanical type.] [B:]**

C. Manufacturers and Products:

1. Best Sign Systems, Montrose, CO; Graphic Blast.
2. Andco Industries Corp., Greensboro, NC; 1400 series.

2.04 GRAPHIC DISPLAY PANEL

A. Design and Construction: As detailed on Drawings.

B. Fabricate in accordance with reviewed Shop Drawings and Samples.

2.05 DOOR NAMEPLATES

A. Material: Plastic with square corners **[A: to match directory] [B:]**.

B. Thickness: **[A: 1/8] [B: 1/16]** inch.

C. Height: 2 inches.

D. Finish: Nondirectional matte.

E. Background: **[A: Black.] [B: Brown.] [C: As scheduled.]**

F. Letters: Raised.

1. Size: 1 inch high.
2. Color: **[A: White.] [B:]**
3. Style: **[C: Helvetica Regular] [D:]** upper **[E: and lower]** case.
4. Message Text: As shown on **[F: Door and Hardware Schedule] [G: Sign Schedule]**.
5. Braille Text: Domed or rounded as required by ADA regulations, with 3/8-inch minimum clearance on all sides.

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G. Manufacturers and Products:

1. Best Sign Systems, Montrose, CO; Graphic Blast.
2. Andco Industries Corp., Greensboro, NC; 1400 series.

2.06 PICTORIAL SYMBOLS

A. Material: Plastic with square corners, **[A: match directory] [B: match door nameplates]**.

B. Conform to ICC A117.1, Section 703.5. Provide Braille text as required by ADA regulation.

C. Manufacturers and Products:

1. Best Sign Systems, Montrose, CO; Graphic Blast.
2. Andco Industries Corp., Greensboro, NC; 1400 series.

2.07 SIGN TYPES

A. Plastic Sign (Type A):

1. Exterior: Laminated plastic subsurface image type, 3/16 inch thick with high-gloss finish.
2. Interior: Plastic, 1/8 inch thick with nondirectional matte finish and raised letters.
3. Rounded corners.

B. Metal Sign (Type B):

1. Material: Baked enamel finished 20-gauge (minimum) steel or 18-gauge (minimum) aluminum signs.
2. Manufacturers:
   a. Seton Identification Products.
   b. Nutheme Illustrated Safety Co.

C. Fiberglass Sign (Type C):

1. Material: Three-ply laminated fiberglass, minimum 1/8 inch thick, with contrasting color core message layer between two clear weather-resistant surface layers.
2. Manufacturers:
   a. Best Sign Systems.
   b. Brady Signmark.

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D. Traffic Sign (Type D):

1. Painted aluminum reflectorized signs, standard design meeting requirements of U.S. Department of Transportation, Federal Highway Administration, Manual on Uniform Traffic Control Devices for Streets and Highways.
2. Materials and Fabrication: **[A: Division 9-28 of the State of Washington Standard Specifications for Road, Bridge, and Municipal Construction] [B: (other as applies)]**.

E. Individual Letter and Number Signs (Type E): **[A: Cast aluminum] [B: Cast bronze] [C: Stainless steel]** for concealed **[D:]** projected **[E: flush]** mounting.

1. Manufacturers:
   a. Eder Metal Letter Co., Milwaukee, WI.
   b. Spanjer Brothers, Inc., Chicago, IL.
   c. Andco Industries Corp., Greensboro, NC.

F. Painted Sign (Type F):

1. Stenciled.
2. Paint System and Surface Preparation: [As specified in Section 09 90 00, Painting and Coating] [_____], as appropriate for material and sign location.

G. Exit Sign (Type G):

1. Material: Plastic, 1/8 inch minimum thickness.
2. Letters:
   a. 6 inches high, with 3/4-inch stroke.
   b. 2 inches wide, except for letter "I", with spacing of 3/8 inch.
3. Colors: Red letters [and direction arrows] on white background.

H. Hazardous Material Sign (Type H):

1. Conform to NFPA 704 and NFPA HAZ-01.
2. Material: [Fiberglass 1/8 inch thick.] [Reflective sheeting applied to 0.040-inch thick aluminum.] [Adhesive vinyl for curved surfaces.]
3. Background, Letters, and Numbers: Die-cut vinyl with pressure sensitive adhesive.
4. Manufacturers:
   a. Brady Signmark.
   b. Emed Co., Inc.

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2.08 IDENTIFICATION LABELS

A. [Pipe Labels:

1. Snap-on, reversible type with lettering and directional arrows, sized for outside diameter of pipe and insulation.
2. Provided with ties or straps for pipes of 6 inches and over diameter.
3. Designed to firmly grip pipe so labels remain fixed in vertical pipe runs.
4. Material: Heavy-duty vinyl or polyester, suitable for exterior use, long lasting, and resistance to moisture, grease, and oils.
5. Letters and Arrows: Black on OSHA safety yellow background.
6. Color Field and Letter Height: Meet ASME A13.1.
7. Message: Piping system name as indicated on Piping Schedule.
8. Manufacturers and Products:
    a. Brady Signmark; B-915 BradySnap-On and Strap-On Pipe Markers.
    b. Seton Identification Products; Ultra-mark Pipe Markers.]

B. [Pipe Labels:

1. Labels: Self-adhesive tape, with separate directional flow [arrows] [arrow banding tape].
2. Material: Pressure sensitive vinyl.
3. Letters and Arrows: Black on OSHA safety yellow background.
4. Color Field and Letter Height: ASME A13.1.
5. Message: Piping system name as indicated on Piping Schedule.
6. Manufacturers and Products:
    a. Brady Signmark; B-946 Self-Sticking Vinyl Pipe Markers and [Vinyl Arrows] [Directional Flow Arrow Tape].
    b. Seton Identification Products; Opti-Code Markers and [Directional Arrows] [Arrows-On-A-Roll Tape].]

C. Equipment Labels:

1. Applies to equipment with assigned tag numbers, where specified.
2. Letters: [Black bold face,] [White engraved,] 3/4 inch minimum high.
3. Background: [OSHA safety yellow.] [Black.]
4. Materials:
    a. [Aluminum or stainless steel with a baked-on finish suitable for use on wet, oily, exposed, abrasive, and corrosive areas.
    b. Fiberglass with encased lettering.]
    c. [Rigid laminate.
    d. Multi-layered acrylic.]
5. Furnish 1-inch margin with holes at each end of label, for mounting. On fiberglass labels, furnish grommets at each hole.
6. Size:

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a. 2 inches minimum and 3 inches maximum high, by 14 inches minimum and 18 inches maximum long.
b. Furnish same size base dimensions for all labels.

7. Message: Equipment names and tag numbers as used in sections where equipment is specified.
8. Manufacturers:
   a. Brady Signmark.
   b. Seton Identification Products.

D. [Chlorinator Room Wall Chart:

1. As specified above for equipment labels, except:
   a. Do not use aluminum labels.
   b. May use engraved exterior grade plastic laminate.
2. Lettering: 1/4 inch high, minimum.
3. Conform to Chlorine Institute WC-1.]

2.09 ANCILLARY MATERIALS

A. Fasteners: Stainless steel screws or bolts of appropriate sizes.

B. Wood Posts: Preservative treated 4 by 4 wood as specified in Section 06 10 00, Rough Carpentry.

C. Pipe Posts: 2-1/2-inch galvanized steel pipe meeting ASTM A53/A53M, Type S, Grade B.

D. Chain: Type 304 stainless steel, No. 16 single jack chain or No. 2 double loop coil chain.

E. Manufacturer’s standard brackets for wall mounting of two-sided exit signs.

PART 3 EXECUTION

3.01 INSTALLATION—GENERAL

A. In accordance with manufacturer’s recommendations.

B. Mount securely, plumb, and level.

3.02 [FACILITY] [BUILDING] NAME PLAQUE

A. Mount [as shown] [_____] with concealed fasteners.

3.03 DIRECTORY

A. Space 1/2 inch from wall with concealed mechanical fasteners.

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3.04 DOOR NAMEPLATES AND PICTORIAL SYMBOLS

A. Attach to doors [or walls adjacent to doors] with [Phillips head screws.] [self-sticking [permanent] [removable] adhesive.] See [Door and Hardware Schedule] [Sign Schedule] for locations and messages.

B. Mount with bottom of nameplate at 5 feet 6 inches above floor.

3.05 SIGNS

A. General:

1. Fasten to walls or posts, or hang as scheduled.
2. Anchor in place for easy removal and reinstallation with ordinary hand tools.

B. Information, Exit, and Safety Signs:

1. Install facing traffic. [Locate for high visibility with minimum restriction of working area around walkways and equipment.]
2. [Install as scheduled.]

C. Traffic Signs: Mount each sign on scheduled support using two 1/4-inch stainless steel bolts through sign and post. [Install facing traffic at locations and in manner shown in U.S. Department of Transportation, Federal Highway Administration Manual on Uniform Traffic Control Devices for Streets and Highways.]

D. Hazardous Material Sign:

1. Install where required by NFPA No. 704 and IFC, Chapter 27.
2. Install at entrances to spaces where hazardous materials are stored, dispensed, used, or handled, and on sides of stationary tanks.
3. Specific Materials:

3.06 IDENTIFICATION LABELS

A. Pipe Labels:

1. Locate at connections to equipment, valves, or branching fittings at wall boundaries.
2. At intervals along piping not greater than 18 feet on center with at least one label applied to each exposed horizontal and vertical run of pipe.
3. At exposed piping not normally in view, such as above suspended ceilings and in closets and cabinets.
4. Supplementary Labels: Provide to Owner those listed on Piping Schedule that do not receive arrows.

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5. Apply to pipe after painting in vicinity is complete, or as approved by Engineer.
6. Install in accordance with manufacturer's instructions.

B. Equipment Labels:

1. Locate and install on equipment or concrete equipment base [as shown on Drawings].
2. Anchor to equipment or base for easy removal and replacement with ordinary hand tools.

C. [Chlorinator Room Wall Chart: Unless otherwise shown, install next to room entrance.]

3.07 SPECIFIC SIGN MESSAGES

A. Polymer Fill Station Format and Message:

1. Polymer Fill Station: This station allows for unloading concentrated polymer from trucks. When operating, wear safety goggles and face shield, rubber gloves, rubber boots, rubber apron, cotton or polyester long-sleeved shirt or rubber jacket, and plastic hard hat.
2. Operating Procedure:
   a. Notify plant personnel prior to unloading. Ask for assistance if needed.
   b. Place corrosion-resistant bucket under bleed valve in fill station.
   c. Remove cap from polymer fill line adapter and make connection between truck hose adapter and polymer fill line adapter.
      1) Open valve on fill line.
      2) Open valve on truck hose.
   d. Unload polymer from truck. Observe level in polymer storage tank at all times by using local level indicator.
   e. When level in storage tank indicates TANK FULL, discontinue unloading of polymer.
      1) Close valve on fill line.
      2) Close valve on truck hose.
   f. Open bleed valve to drain polymer between fill line valve and truck hose valve into bucket.
   g. Close bleed valve.
   h. Use caution to break connection between truck hose adapter and polymer fill line adapter.
   i. Replace cap on polymer fill line adapter.
   j. Remove bucket and pour waste polymer either back into delivery truck or into a water-holding basin at a location selected by plant operating personnel. Thoroughly rinse bucket by submerging bucket in water basin.

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3. In Case of Emergency: Immediately flush contaminated skin or eyes with water at safety shower and eyewash. Notify plant personnel. Follow procedures outlined in polymer Material Safety Data Sheet.

3.08 SUPPLEMENTS

A. The supplement listed below, following “End of Section,” is a part of this specification.

1. Sign Schedule: Tabulation of characteristics and mounting information for warning, informational and unlighted exit signs [on Project] [numbered on Drawings]. Provide items as scheduled. Meet requirements of Occupational Safety and Health Act (OSHA).
2. Hazardous Material Sign Schedule: Tabulation and mounting information for signs conforming to NFPA 704 and NFPA HAZ-01.

END OF SECTION

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SECTION 10 21 00
COMPARTMENTS AND CUBICLES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American National Standards Institute (ANSI):
   a. A117.1, Accessible and Usable Buildings and Facilities.
2. Americans with Disabilities Act (ADA).
3. ASTM International (ASTM):
   a. A276, Specification for Stainless Steel Bars and Shapes.
   b. A591/A591M, Standard Specification for Steel Sheet, Electrolytic Zinc-Coated, for Light Coating Weight [Mass] Applications.
   c. A653/A653M, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
   d. A666, Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar.
   e. F593, Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
   f. F594, Specification for Stainless Steel Nuts.
4. Federal Specifications, Standards and Commercial Item Descriptions, (FS): A-A-60003, Partitions, Toilet, Complete.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings: Include plans, sections, elevations, material descriptions, dimensions, and attachments to other work.
   a. Show locations of cutouts for compartment-mounted grab bars.
   b. Show locations of reinforcements and attachments for compartment-mounted toilet accessories.
   c. Product Data: Manufacturer's detailed technical data for toilet compartments and urinal screens specified. Include details of anchors, hardware, and fastenings.

1.03 QUALITY ASSURANCE

A. Fabricator Qualifications: Shop that employs skilled workers who custom fabricate products similar to this Project with a minimum of 5 years' experience in similar sized projects.

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1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to project site in undamaged condition.

B. Store and handle metal and related materials to prevent deterioration or damage as a result of moisture, temperature changes, contaminants, corrosion, breakage, chipping, or warping.

C. Stack or brace metal on edge on leveled and adequate A-frames in a manner that prevents undue stresses causing chipping, cracking, and breaking.

PART 2 PRODUCTS

2.01 METAL UNITS

A. Stainless Steel Units: Facing sheets and closures fabricated from ASTM A666, Type 302 stainless steel or Type 304, stainless steel sheet, leveled to stretcher-leveled flatness.

1. Stainless Steel Facing Sheet Thicknesses: Specified thicknesses as follows:
   a. Pilasters, Braced at Both Ends: Manufacturer's standard thickness, but not less than 0.0375 inch (0.95 mm).
   b. Panels: Manufacturer's standard thickness, but not less than 0.0312 inch.
   c. Doors: Manufacturer's standard thickness, but not less than 0.0312 inch (0.8 mm).
   d. Integral-Flange, Wall-Hung Urinal Screens: Manufacturer's standard thickness, but not less than 0.0312 inch (0.8 mm).
2. Finish: No. 4 bright, directional polish on exposed faces. Protect exposed surfaces from damage by application of strippable, temporary protective covering before shipment.

B. Door, Panel, and Pilaster Construction: Seamless, metal facing sheets pressure laminated to core material. Units to have continuous, interlocking molding strip or lapped and formed edge closures. Exposed surfaces free of pitting, seam marks, roller marks, stains, discolorations, telegraphing of core material, or other imperfections. Corners sealed by welding. Exposed welds are ground smooth.

1. Core Material: Manufacturer's standard sound-deadening honeycomb of resin-impregnated kraft paper in thickness required to provide finished thickness of 1 inch (25 mm) for doors and panels and 1-1/4 inches (32 mm) for pilasters.
2. Grab-Bar Reinforcement: Provide concealed internal reinforcement for grab bars mounted on units.

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3. Tapping Reinforcement: Provide concealed reinforcement for tapping (threading) at locations where machine screws are used for attaching items to units.
4. Urinal-Screen Construction: Matching panels.

C. Pilaster Shoes: Stainless steel, ASTM A666, Type 302 or Type 304, not less than 0.0312 inch (0.8 mm) specified thickness and 3 inches (75 mm) high, finished to match hardware.

D. Brackets (Fittings):

1. Stirrup Type: Ear or U-brackets, stainless steel.
2. Full-Height (Continuous) Type: Manufacturer's standard design; stainless steel.

E. Manufacturers:

1. Accurate Partitions Corporation.
2. Bradley Corporation; Mills Partitions.
3. Sanymetal; a Crane Plumbing Company.

2.02 ACCESSORIES

A. Exposed Anchors and Fasteners: Stainless steel fasteners with theft-resistant-type heads. Provide sex-type through bolts with theft-resistant spanner heads and threaded brass rods for attachments to stone.

B. Bolts, Nuts, and Washers: Provide Type 304 stainless steel bolts complying with ASTM F593, nuts complying with ASTM F594, and washers and lock washers for connection to overhead support as indicated.

C. Sealant: Nonstaining, compatible sealant recommended by compartment fabricator for components and joints indicated.

1. Use sealant that has a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.03 FABRICATION

A. General:

1. Provide standard doors, panels, screens, and pilasters fabricated for compartment system.
2. Provide units with cutouts and drilled holes to receive compartment-mounted hardware, accessories, and grab bars, as indicated.
3. Provide internal reinforcement in metal units for compartment-mounted hardware, accessories, and grab bars, as indicated.

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B. Metal-Faced Toilet Compartments and Screens:

1. Pressure laminate seamless face sheets to core material and provide continuous, interlocking molding strip or lapped and formed edges.
2. Seal corners by welding or clips.
3. Grind exposed welds smooth.

C. Doors: Unless otherwise indicated, provide 24-inch (610-mm) wide in-swinging doors for standard toilet compartments and 36-inch (914-mm) wide out-swinging doors with a minimum 32-inch (813-mm) wide clear opening for compartments indicated to be handicapped accessible.

1. Hinges: Manufacturer's standard self-closing type that can be adjusted to hold door open at any angle up to 90 degrees.
2. Latch and Keeper: Recessed latch unit designed for emergency access and with combination rubber-faced door strike and keeper. At compartments indicated to be handicapped accessible, provide units that comply with accessibility requirements of authorities having jurisdiction.
3. Coat Hook: Manufacturer's standard combination hook and rubber-tipped bumper; sized to prevent door from hitting compartment-mounted accessories.
4. Door Bumper: Manufacturer's standard rubber-tipped bumpers at out-swinging doors or entrance screen doors.
5. Door Pull: At out-swinging doors, manufacturer's standard unit that complies with accessibility requirements of authorities having jurisdiction. Provide units on both sides of doors at compartments indicated to be handicapped accessible.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine substrates, areas, and conditions, with installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

C. Coordinate layout and installation of supports, inserts, and anchors built into other units of work for toilet compartment anchorage.

3.02 INSTALLATION

A. General:

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1. Comply with manufacturer's written installation instructions.
2. Install units rigid, straight, level, and plumb.
3. Secure units in position with manufacturer's recommended anchoring devices.
4. Maximum Clearances:
    a. Pilasters and Panels: 1/2 inch (13 mm).
    b. Panels and Walls: 1 inch (25 mm).
5. Stirrup Brackets: Secure panels to walls and to pilasters with not less than three brackets attached at midpoint and near top and bottom of panel.
    a. Locate wall brackets so holds for wall anchors occur in masonry or tile joints.
    b. Align brackets at pilasters with brackets at walls.

B. Overhead-Braced Units:

1. Secure pilasters to floor and level, plumb, and tighten.
2. Secure continuous head rail to each pilaster with not less than two fasteners.
3. Hang doors to align tops of doors with tops of panels and adjust so tops of doors are parallel with overhead brace when doors are in closed position.

C. Floor-Anchored Units:

1. Set pilasters with anchors penetrating not less than 2 inches (50 mm) into structural floor, unless otherwise indicated in manufacturer's written instructions.
2. Level, plumb, and tighten pilasters.
3. Hang doors and adjust so tops of doors are level with tops of pilasters when doors are in closed position.

3.03 ADJUSTING AND CLEANING

A. Adjust and lubricate hardware for proper operation. Set hinges on in-swinging doors to hold open approximately 30 degrees from closed position when unlatched. Set hinges on out-swinging doors **[A: and entrance swing doors]** to return to fully closed position.

B. Clean exposed surfaces of partition systems using materials and methods recommended by manufacturer, and provide protection as necessary to prevent damage during remainder of construction period.

END OF SECTION

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SECTION 10 28 00
TOILET AND BATH ACCESSORIES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. National Fire Protection Association (NFPA): 701, Standard Methods of Fire Tests for Flame Propagation of Textiles and Films.

1.02 DESIGN REQUIREMENTS

A. Design grab bars, and attachments to resist forces as required by code designated in Section 01 61 00, Common Product Requirements.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Manufacturer's literature clearly indicating:
      1) Engineer's identification mark, size, and description of components.
      2) Base material with surface finish inside and out.
      3) Hardware and locks and attachment devices.
      4) Description of rough-in framing.
      5) Details of blocking and anchorage required.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Materials and products specified in this section shall be products of:

1. Bobrick Washroom Equipment, Inc.
2. Bradley Corp.

2.02 TOILET AND BATH ACCESSORIES

A. Furnish accessory items listed where indicated by mark or note on Drawings.

Item	Mark	Bobrick	Bradley
Surf. Mounted Dual Roll Toilet Paper Dispenser	TPD-1	No. B-2740	No. 5241-50

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Item	Mark	Bobrick	Bradley
Wall Mounted Liquid Soap Dispenser	SD-2	No. B-4112	No. 6542
Mirror, Size on Dwgs	MIR	No. B-290	No. 780
Surf. Mounted Paper Towel Dispenser	PTD-2	No. B-262	No. 250-15
Surf. Mounted Paper Towel Dispenser and Receptacle	PTD/R-1	No. B-3949	No. 235-11
Surf. Mounted Seat Cover dispenser	SCD-2	No. B-221	No. 5831
Mop and Broom Holder (24")	M&BH	No. B-223 x 24	No. 9953
Robe Hook	RH	No. B-6727	No. 9124
Grab Bars (straight) (36")	GB-1	No. B-6806-36	No. 812-001-36
Grab Bars (straight) (42")	GB-2	No. B-6806-42	No. 812-001-42
Grab Bars (straight), 18" for Vertical Mounting	GB-3	No. B-6806-18	No. 812-001-18
Shower Curtain Rod	SCR	No. B-207	No. 9538
Flame Resistant and Antibacterial Shower Curtain with Hooks	SC	No. B-204-2/204-1	No. 9537/9536

B. Finish:

1. Satin stainless steel.
2. Manufacturer’s or brand name on face of units is not acceptable.

C. Anchors: Furnish anchors, fasteners, or other devices necessary for a complete, secure installation.

1. Fasteners: Tamper-proof screws or bolts.

D. Supplies: Furnish fill supplies, such as paper goods, soap, and napkins, as recommended by accessory manufacturer.

PART 3 EXECUTION

3.01 PREPARATION

A. Coordinate support framing and backing as necessary for proper installation of accessories.

B. Coordinate the Work with placement of internal wall reinforcement and reinforcement of toilet partitions to receive anchor attachments.

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3.02 INSTALLATION

A. Mounting Heights and Locations: Locate where mark is shown on Drawings at height required by accessibility regulations.

B. Follow manufacturer’s instruction and recommendations.

C. Install and securely anchor accessories in their proper locations, plumb and level, and without distortion.

D. Remove protective masking and clean surfaces, leaving them free of soil and imperfections.

E. Fill units with necessary supplies within 10 days before Substantial Completion.

F. Deliver to Engineer keys and devices required to fill and service units.

3.03 CLEANING

A. Clean and repair existing toilet accessories which remain or are to be reinstalled.

END OF SECTION

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SECTION 10 44 00
FIRE PROTECTION SPECIALTIES AND SAFETY EQUIPMENT

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Factory Mutual (FM).
2. National Fire Protection Association (NFPA):
   a. 10, Standard for Portable Fire Extinguishers.
   b. 30, Flammable and Combustible Liquids Code.
3. National Institute for Occupational Safety and Health (NIOSH).
4. Occupational Safety and Health Administration (OSHA).
5. Underwriters Laboratories Inc. (UL): Fire Protection Equipment Directory.

1.02 PERFORMANCE REQUIREMENTS

A. Conform to NFPA 10.

B. Provide extinguishers classified and labeled by Underwriters Laboratories Inc. for purpose specified and indicated.

C. Provide key boxes as required by the applicable code or by the fire marshal or code official having jurisdiction.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Fire Extinguishers: Manufacturer’s product data for each item, including sizes, ratings, UL listings, or other certifications, and mounting information.
   b. Extinguisher Cabinets and Key Boxes: Indicate type of cabinet, cabinet physical dimensions, location, mounting methods and anchorage details, relationship of cabinet box and trim to surrounding construction, door type and hardware, trim style, panel style.
   c. Product Data: Extinguisher operational features, color and finish, and anchorage details.

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B. Informational Submittals:

1. Manufacturer's Certificate: Certify Products meet or exceed specified requirements.
2. Operation and Maintenance Data: Submit test, refill or recharge schedules and recertification requirements.

1.04 ENVIRONMENTAL REQUIREMENTS

A. Section 01 61 00, Common Product Requirements: Environmental conditions affecting products onsite.

B. Do not install extinguishers when ambient temperatures are capable of freezing extinguisher ingredients.

PART 2 PRODUCTS

2.01 PORTABLE FIRE EXTINGUISHERS

A. Manufacturers:

1. JL Industries.
2. Larsen's Manufacturing Co.
3. Nystrom Products Co.

B. General:

1. Conform to NFPA 10 for fire extinguishers.
2. Furnish fire extinguishers and cabinets from one manufacturer.
3. UL listed, charged and ready for service.

C. Multipurpose Hand Extinguisher (F. Ext-1):

1. Tri-class dry chemical extinguishing agent.
2. Pressurized, red enameled steel shell cylinder.
3. Activated by top squeeze handle.
4. Agent propelled through hose or opening at top of unit.
5. For use on A, B, and C class fires.
6. Minimum UL Rating: 4A-60B:C, 10-pound capacity.

D. Carbon Dioxide Hand Extinguisher (F. Ext-2):

1. Carbon dioxide.
2. Pressurized, red enameled steel shell cylinder.
3. Activated by top squeeze handle.
4. Agent propelled through hose and spreader nozzle.
5. For use on B and C class fires.
6. Minimum UL Rating: 10B:C, 15-pound capacity.

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2.02 FIRE EXTINGUISHER CABINETS

A. Manufacturers:

1. J. L Industries.
2. Larsen’s Manufacturing Co.

B. Extinguisher Cabinet Type:

1. Semi-recessed.
2. Sized to accommodate accessories.

C. Metal: Formed sheet steel, galvanized and painted; 0.036 inch thick base metal.

D. Trimless Type: Returned to wall surface, with rolled edge.

E. Door: 0.016-inch thick, reinforced for flatness and rigidity; latch, full glass door access.

F. Door Glazing: Glass, clear, 1/8-inch thick tempered.

G. Cabinet Mounting Hardware: Appropriate to cabinet and wall type.

H. Hinge doors for 180-degree opening. Weld, fill, and grind components smooth.

I. Finishing Cabinet Exterior Trim and Door: Red baked enamel, color.

2.03 KEY BOXES

A. Manufacturers and Products:

1. Knox Company, Phoenix, AZ.
2. Kidde Fire Safety; SupraSafe, Mebane, NC.

B. Steel high-security commercial key vault, minimum 6 inches wide by 6 inches tall with hinges door; ; UL listed; and resists moisture and weather by use of a gasketed exterior door. Unit is to be recessed into exterior wall or fence/gate using special mounting kit.

2.04 FLAMMABLE LIQUID STORAGE CABINET

A. Size: 30-gallon capacity, 43 inches wide by 18 inches deep by 44 inches high with one adjustable shelf.

B. Cabinet: 18-gauge welded steel with two swinging doors complying with NFPA No. 30, current OSHA Standards, and FM-approved or UL-listed.

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C. Finish: Safety yellow baked enamel. Mark front with red letters reading FLAMMABLE LIQUID-KEEP FIRE AWAY.

2.05 FIRST-AID CABINETS AND SUPPLIES

A. Manufacturers:

1. Afassco, Inc.
2. Johnson & Johnson.
3. Zee Medical Products Co., Inc.

B. Cases:

1. Enameled metal or break-resistant plastic.
2. Carrying handles.
3. Made to hang on wall.

C. Supplies: Quantities to serve 30 people.

2.06 ACCESSORIES

A. Extinguisher Brackets: For hand extinguishers not located in cabinets, furnish heavy-duty brackets with clip-together strap for wall mounting galvanized finish.

B. Fasteners: Furnish necessary screws, bolts, brackets, and other fastenings of suitable type and size to secure items of fire and safety equipment in position.

1. Metal expansion shields for machine screws at concrete and masonry.
2. Interior: Rust-resistant.
3. Exterior: Stainless steel.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify cabinets are correctly sized for fire extinguisher type.

B. Verify rough openings for cabinet are correctly sized and located.

3.02 INSTALLATION

A. Install where indicated or directed and in accordance with manufacturer's recommendations.

B. Install cabinets plumb and level in wall openings, maximum 48 inches from finished floor to top of extinguisher handle.

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C. Secure cabinets and brackets rigidly to structure.

D. Provide adequate backing for mounting surfaces.

3.03 PORTABLE FIRE EXTINGUISHERS AND CABINETS

A. Provide at locations shown or as directed by Engineer.

B. Mount hangers securely in position, following manufacturer's recommendations.

C. Top of Extinguisher: No more than 54 inches above floor.

END OF SECTION

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SECTION 10 51 00
LOCKERS

PART 1 GENERAL

1.01 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Anchorage and bracing drawings and/or catalog information, as required by Section 01 88 15, Anchorage and Bracing, for loads provided in Section 01 61 00, Common Product Requirements.
2. Manufacturer's literature describing products proposed for use.
3. Color Samples: Three each for colors scheduled in the Interior Finish Schedule on the Drawings.

B. Informational Submittals: Installation instructions.

PART 2 PRODUCTS

2.01 LOCKERS

A. Type: Standard, single-tier, single-door type made of cold-rolled sheet metal.

1. Locker sides, backs, tops, bottoms, and shelves; minimum 24-gauge steel.
2. Doors and frames; minimum 16-gauge steel.

B. Size: 15 inches by 18 inches.

C. Top: 20-gauge sloping top.

D. Bottom: Flat for mounting on raised base.

E. Doors: Standard, with louvers top and bottom.

F. Filler Panels: Manufacturer's standard, 24-gauge, to suit locker arrangement shown on Drawings.

G. Hinges and Door Strikes: Manufacturer's standard continuous type.

H. Locks: combination padlock and combination for each locker.

I. Shelves: One hat shelf with rolled front.

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J. Coat Hooks: Three single-prong wall hooks and one double-prong ceiling hook in each compartment.

K. Number Plates: Noncorrosive with black numerals, numbered consecutively beginning with one in each room.

L. Finish: Powder-coat, over bonding and rust-resisting phosphate undercoat.

M. Color: As indicated in Interior Finish Schedule.

N. Anchor Bolts: Minimum 1/2-inch diameter (unless a larger minimum size is shown on Drawings) Type 316 stainless steel; total number and final size as required by equipment manufacturer and by Contractor's anchorage and bracing design per Section 01 88 15, Anchorage and Bracing. Anchor bolts shall be as specified in Section 05 50 00, Metal Fabrications.

O. Manufacturers:

1. Lyon Workspace Products.
2. Penco Products, Inc.
3. Republic Storage Systems Company.

2.02 LOCKER BENCHES

A. Tops:

1. High-density polyethylene (HDPE) formed under pressure into single component section, with homogenous color throughout.
2. 20 inches wide by 42 inches in length and minimum 1-3/8 inches thick.
3. Manufacturer's standard plastic sealer finish.

B. Pedestals:

1. Aluminum.
2. Heavy-duty tubes welded to top and bottom flanges.
3. 17 inches high, minimum.
4. Floor anchored. Anchor bolts minimum 1/2-inch diameter (unless a larger minimum size is shown on the Drawings) Type 316 stainless steel; total number and final size as required by equipment manufacturer and by Contractor's anchorage and bracing design per Section 01 88 15, Anchorage and Bracing. Anchor bolts shall be as specified in Section 05 50 00, Metal Fabrications.
5. Spacing as recommended by manufacturer, but not to exceed 3 feet on center.
6. Finish and Color: Manufacturer's standard.

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C. Manufacturers:

1. Comtec Industries.
2. Santana Plastic Products.

PART 3 EXECUTION

3.01 LOCKER INSTALLATION

A. Securely attach to wall, base, and to each other as recommended by manufacturer. Accurately place anchor bolts using templates furnished by equipment manufacturer and as specified in Section 05 50 00, Metal Fabrications.

B. Align and level lockers with shims where necessary to compensate for irregularities in the base.

C. Install trim, adjust doors and latches for proper operation, and leave lockers level, plumb, neat, rigid, and free from soil and imperfections.

3.02 LOCKER BENCH INSTALLATION

A. Install to meet ADA Guidelines for barrier free access.

B. Attach pedestals to top with fasteners supplied by manufacturer and secure to floor with anchors recommended by manufacturer. Accurately place anchor bolts using templates furnished by equipment manufacturer and as specified in Section 05 50 00, Metal Fabrications.

END OF SECTION

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SECTION 10 80 00
MISCELLANEOUS SPECIALTIES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes:

1. Mail Sorter.
2. Writing board.
3. Tackboard.
4. White Board Projection Screen.
5. Metal shelving.
6. Metal storage bins.
7. Metal workbenches.
8. Stools.
9. Recessed floor mat and frame.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM): D1187, Standard Specification for Asphalt-Base Emulsions for Use as Protective Coatings for Metal.
2. UL (UL): Building Materials Directory.

1.03 SUBMITTALS

A. Action Submittals:

1. Manufacturers' product data for proposed items. Clearly identify each item.
2. Manufacturers' color charts.
3. **[A: Anchorage and bracing drawings and/or catalog information, as required by Section 01 88 15, Anchorage and Bracing, for loads provided in Section 01 61 00, Common Product Requirements.]**

B. Informational Submittals:

1. Manufacturers' installation instructions.
2. Manufacturers' cleaning and service instructions for proposed items.
3. **[A: Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing, for loads provided in Section 01 61 00, Common Product Requirements. Submit with Action Submittal for the same item.]**

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PART 2 PRODUCTS

2.01 MAIL SORTER (M-1):

A. Materials: Steel cabinet for wall or desk mounting, powder coated finish, manufacturer's standard tan color.

B. Composition: 12 open mail slots, overall 34 inches by 12 inches by 15 inches, with 1/2 inch shelf lip for labeling each bin.

C. Manufacturers and Products:

1. ULINE; Mail Sorter, H-2921.
2. Or approved equal.

2.02 WRITING BOARDS (M-2):

A. Materials: Stretcher level sheet steel facing, 24-gauge minimum, bonderized and surfaced to accept watercolor and semipermanent writing inks with selective erasability, minimum 3/8-inch particleboard core, 0.015-inch aluminum backing sheet, extruded aluminum frame and tray.

B. Composition: Facing sheet and backing sheet bonded to opposite sides of core.

C. Finish and Color: White porcelain enamel semigloss writing surface finish impervious to cracking, checking, chipping, and peeling; clear anodized finish on extruded aluminum frame and tray.

D. Size: 3 feet by 4 feet.

E. Accessories: Twelve watercolor markers, six black and six assorted colors compatible with writing surface; cleaners, towels, magnetic strips, and instruction booklet.

F. Manufacturers and Products:

1. AARCO Products, Inc., Yaphank, NY; Series 10-120 and 10-008.
2. Claridge Products & Equipment, Inc., Harrison, AR; Series 4, Type A.
3. Lemco, Inc., West Jordan, UT; Type 3, No. 250.

2.03 TACKBOARDS (M-3):

A. Materials: 1/4-inch vinyl-impregnated cork; 1/4-inch tempered hardboard backing; extruded aluminum frame without tray.

B. Composition: Cork face sheet, factory cemented to backing.

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C. Finish and Color:

1. Ground natural cork with washable vinyl finish and integral color throughout.
2. Cork Surface Color and Texture: Natural; clear anodized finish on extruded aluminum frame.

D. Size: 3 feet by 4 feet.

E. Accessories: Clip angle hangers at 24 inches on center top and bottom.

F. Manufacturers and Products:

1. AARCO Products, Inc., Yaphank, NY; Series 10-120 and 10-015.
2. Claridge Products & Equipment, Inc., Harrison, AR; Series 4, Type CO.
3. Lemco, Inc., West Jordan, UT; Type 3, No. 311

2.04 WHITE BOARD PROJECTION SCREEN (M-4):

A. Materials: Porcelain steel writing surface over solid backing with aluminum frame and full length tray.

B. Screen surface specifically designed for dual use as dry-erase marker board and projection screen with controlled reflection and reduced hot spots.

C. Finish and Color:

1. Screen; White.
2. Frame and tray: Anodized, clear.

D. Size: 50 inches high by 168 inches wide..

E. Accessories:

1. Standard clips and fasteners for concealed wall mounting.
2. One set of manufacturer’s recommended markers and eraser.

F. Manufacturers:

1. Da-Lite; IDEA Panoramic Screen, 27959T.
2. Or Approved Equal.

2.05 METAL SHELVING (M-5):

A. Materials: Cold-rolled steel sheet, component thicknesses in manufacturer’s standard gauges; hot-rolled steel for structural components.

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B. Composition: Open type steel shelving with reinforced sheet metal shelves and dividers.

C. Finish and Color: Baked enamel, in tan color.

D. Size: Unit 3 feet wide by 1-1/2 feet deep and 7 feet high with six shelves placed with 12-inch-high openings.

E. Accessories: Clips and attachment fittings for shelf assembly, adjustment, and seismic anchorage.

F. Manufacturers and Products:

1. Lyon Workspace Products, Montgomery, IL; 8044.
2. Equipto, Addison, TX; 62-6.

2.06 METAL STORAGE BINS (M-6):

A. Materials: Manufacturer’s standard heavy-duty gauge sheet steel.

B. Composition: Storage bin type steel shelving with reinforced sheet metal ends, shelves, and adjustable dividers, and clips for shelf assembly and adjustment.

C. Finish and Color: Baked enamel in tan color.

D. Size: Unit 3 feet wide by 2 feet deep and 7 feet high with 8 shelves divided into 29 bin openings of various sizes.

E. Manufacturers and Products:

1. Lyon Workspace Products, Montgomery, IL; 8075.
2. Equipto, Addison, TX; 913E.

2.07 METAL WORKBENCHES (M-7):

A. Materials: Top of tempered hardboard bonded to wood.

B. Composition: Constructed of welded steel leg units with back stringer and top.

C. Finish and Color: Baked enamel in tan color.

D. Size: Open leg design workbench units 72 inches long by minimum 34 inches deep by minimum 34 inches high.

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E. Accessories:

1. Foot rest.
2. Two steel drawer(s) approximately 14 inches wide by 20 inches deep by 5 inches high with padlock attachment.
3. Back and end stops.
4. ingle aerial shelf at back of top.

F. Manufacturers and Products:

1. Lyon Metal Products Inc., Aurora, IL.; Lyon 2500 Series.
2. Republic Steel, Canton, OH; Republic Command 10 Series.

2.08 STOOLS (M-8):

A. Description: No arms, hard-floor casters, steel frame and fixed foot ring, pneumatic cylinders, high resilience molded foam seat.

B. Finish and Color: Powder coated finish in manufacturer's standard tan color; black seat.

C. Size: 28 inches by 44.25 inches high.

D. Manufacturers and Products:

1. Cramer Inc; Rhino Stool.
2. Or approved Equal.

2.09 RECESSED FLOOR MATS AND FRAMES (M-9)

A. Mat Frame:

1. Materials: Extruded aluminum 6063 T-5 frame.
2. Composition: Recess mat frame prefabricated at the factory to ensure fit of mat, furnished complete with corner pins of aluminum and anchor pins of strap steel.
3. Finish: Mill.
4. Manufacturers and Products:
   a. American Floor Products Company, Inc., Gaithersburg, MD; No. MF-153.
   b. R. C. Musson Rubber Co., Akron, OH; No. RF-14.
   c. Pawling Corporation, Wassaic, NY; No. MRF-1002.

B. Vinyl Link Mat:

1. Material Composition: Highly resilient, top quality vinyl compound, 1/2 inch wide by 2 inches long by 7/16 inch thick with at least five

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wiping blades on each side of the link; apertures between links not to exceed 1/8 inch by 1/2 inch; 13-gauge double galvanized spring steel wire framework.

2. Color: Black.
3. Size: As indicated on Drawings.
4. Manufacturers and Products:
   a. American Floor Products Company, Inc., Gaithersburg, MD; AL-109.
   b. R. C. Musson Co., Akron, OH; No. CW-16.
   c. Pawling Corporation, Wassaic, NY; Parco-Link LM-100.

2.10 ISOLATION PAINT

A. Coating in accordance with Section 09 90 00, Painting and Coating.

PART 3 EXECUTION

3.01 INSTALLATION OF SPECIALTIES

A. Follow manufacturer's recommendations and printed instructions. Consult with Engineer in order that minor adjustments in locations can be decided if necessary.

1. Install materials plumb or level as applicable and attach securely to adjacent materials with suitable fasteners.
2. Prevent scratching or damaging adjacent materials during installation.
3. Apply isolation paint to specialty item where metal comes in contact with dissimilar metal or is in contact with concrete or soil.

B. Metal Shelving and Storage Bins:

1. Assemble shelving units and storage bins following manufacturer's instructions.
2. Securely fasten units together and anchor to prevent overturning during seismic event. Arrange shelves and bin sizes as directed by Engineer.
3. Touch up scratches or defaced finish after assembly as directed by Engineer.

C. Metal Workbenches: Assemble and install workbenches as recommended by manufacturer.

D. Floor Mats and Frames:

1. Assemble frame to suit mat thickness and securely anchor in-place following manufacturer's instructions. Place cement grout base as recommended by manufacturer below floor level, screeded into the interior frame area, using the edge of frame as a guide.

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2. Install mat in frame recess as recommended by manufacturer, flat and without curls or humps.

END OF SECTION

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SECTION 11 31 00
APPLIANCES

PART 1 GENERAL

1.01 SUBMITTALS

A. Action Submittals: Manufacturer's literature including specifications, operating and cleaning instructions, and color chart. Identify each unit with Engineer's item number.

PART 2 PRODUCTS

2.01 MANUFACTURED UNITS

A. Refrigerator, A-1: Refrigerator with top freezer, no-frost, 14.6-cubic-foot capacity, with adjustable shelves, two crispers, and energy saving feature; Energy-Star rating; White.

1. Manufacturers and Products:
   a. General Electric; GTE 15 CTHRWW.
   b. Or approved equal.

B. Disposer, A-2: Continuous feed, acoustical insulated, food waste disposer with 3/4-hp motor.

1. Manufacturers and Products:
   a. Kitchen Aid; KCDSO75T.
   b. Or approved equal.

C. Microwave Oven, A-3: Countertop model, 2.2 cubic feet cooking area, 1,100 cooking watts, white.

1. Manufacturers and Products:
   a. General Electric; GE PEB 7226 DFWW.
   b. Or approved equal.

PART 3 EXECUTION

3.01 INSTALLATION

A. Following manufacturers' instructions and recommendations, install and connect appliances in the proper location and leave them ready for use.

B. Locate clock at every clock outlet shown on Electrical Drawings.

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C. Remove all protective maskings and clean surfaces, leaving them free of soil and imperfections.

END OF SECTION

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SECTION 11 53 00
LABORATORY EQUIPMENT

PART 1 GENERAL

1.01 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Brochures and catalogs.
   b. Descriptive literature.
   c. Manufacturer's specifications.

B. Informational Submittals:

1. Statements of manufacturers' and installers' qualifications.
2. Installation instructions.
3. Operation and Maintenance Data: As specified in Section 01 78 23, Operation and Maintenance Data.
4. Repair instructions.
5. Book on specific analytical methods associated with analytical equipment.
6. Manufacturer's Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers' Field Services.
7. Service agreements.
8. List of service costs after service agreement expires.
9. Information on local service, durability, and parts availability.
10. List of future training topics, rates, and locations.
11. Special guarantees.

1.02 QUALITY ASSURANCE

A. Qualifications of Manufacturers: 3 years' experience specializing in manufacturing products specified.

B. Installers: Trained representatives of manufacturers.

1.03 DELIVERY, STORAGE, AND HANDLING

A. Packing and Shipping:

1. Ship as follows:
   a. Ship in factory packaging with contents of each identified.
   b. Attach handling and installation instructions.

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B. Delivery: Do not deliver chemicals to the Site earlier than 30 days before laboratory startup. Deliver chemicals with a minimum remaining shelf life of 6 months after the time of Substantial Completion.

C. Acceptance at Site: Coordinate delivery with Engineer and Owner, who may wish to inspect items in presence of Contractor to verify condition.

D. Handling: Provide temporary skids under products greater than 150 pounds.

E. Storage and Protection:

1. Inventory delivered products.
2. Store in an area protected from deleterious elements.
3. Protect in a manner that prevents damage and as recommended by product manufacturer.

1.04 SPECIAL GUARANTEE

A. Provide manufacturer's extended guarantee or warranty, with Owner named as beneficiary, in writing, as special guarantee. Special guarantee shall provide for correction, or at the option of the Owner, removal and replacement of Work specified in this Specification section found defective during a period of 1 year after the date of Substantial Completion. Duties and obligations for correction or removal and replacement of defective Work as specified in the General Conditions.

B. Provide for each piece of equipment furnished.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Materials, equipment, and accessories specified in this section shall be products of:

1. Thermo Fisher Scientific, Inc. (TFS).
2. Hach Company (HACH).
3. Lachat Instruments (LCTI).
4. EMD Millipore Corp. (MILL).
5. Perkin-Elmer Inc. (PE).
6. Agilent Technologies (AGL).
7. VWR International LLC (VWR).
8. Waters Corporation (WAT).
9. Shimadzu Corporation (SHZ).
10. Teledyne Leeman Labs (TLL).
11. Market Forge Industries, Inc. (MFII).
12. Mettler Toledo (MET).

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13. Sartorisu (SAT).
14. Environmental Express (ENEV).
15. YSI, Inc. (YSI).
16. Grainger Industrial Supply (GIS).

2.02 LABORATORY EQUIPMENT

A. General Equipment and Supplies:

Qty Req.	Item Description	Manufacturer/Supplier No.		
		TFS	VWR	HACH
1	Deionized Water System, wall mounted - LWS-1			
1	Deionized Water System, tank - LWS-2			
1	Sample Storage Refrigerator, Full Size			
1	Vacuum Pump			
1	UV/VIS Spec			
1	Chlorine Residual Spec			
1	Block Digestor			
1	Meter with pH and conductivity probes			
1	Buret and stand			
1	Filtration Apparatus			
1	Turbidimeter			
1	Jar Tester			

PART 3 EXECUTION

3.01 INSPECTION AND PREPARATION

A. Examine locations for conditions that would prevent quality installation.

B. Verify service connections are correct.

C. Do not proceed with installation until defects are corrected.

3.02 INSTALLATION

A. Install in accordance with manufacturer’s instructions in new and ready-to-use condition.

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B. Install with utility connections that are compatible with service and outlets provided.

C. Furnish the necessary initial supply of parts, accessories, lubricants, and/or chemicals required by the equipment.

3.03 MANUFACTURER'S SERVICES

A. Provide manufacturer's representative at Site in accordance with Section 01 43 33, Manufacturers' Field Services, for installation assistance, inspection and certification of proper installation, equipment testing, startup assistance, and training of Owner's personnel for equipment provided.

B. Factory-Trained Service Engineer:

1. Test equipment prior to demonstration.
2. Ensure equipment, including specified accessories, is operational.
3. At completion of Work, provide qualified and trained applications specialist to demonstrate operation of each item of equipment and instructs Owner in operating procedures and maintenance.

C. Demonstration:

1. Schedule demonstration minimum 2 weeks in advance and after operation and maintenance data has been submitted.
2. Demonstrate equipment to familiarize the Owner on planned operation and maintenance, including periodic preventive maintenance measures required. Include explanation of service requirements and simple on Site service procedures, as well as information concerning name, address, and telephone number of qualified local source of service.

D. Training:

1. Train three representatives of Owner on planned equipment operation and maintenance for one 8-hour day at Owner's location.
2. Make written report of demonstration and training to the Owner's representative outlining equipment used and malfunctions or deficiencies noted. Identify individuals present at demonstration. Issue certificates showing:
    a. Installation is as specified and acceptable to the manufacturer.
    b. Manufacturer's warranty is in full effect beginning on the date of certification with no qualifications or reservations.

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3.04 ADJUSTING AND CLEANING

A. Remove protective wrappings and clean surfaces ready for use.

B. Test and adjust equipment and hardware and leave in perfect working order.

C. Restore stained or discolored finishes or install new item.

D. Protect installed Work from damage.

3.05 SUPPLEMENTS

A. The supplement listed following “End of Section,” is a part of this Specification.

1. Laboratory Equipment Schedule.

END OF SECTION

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SECTION 12 35 53
LABORATORY CASEWORK

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American National Standards Institute (ANSI):
   a. A135.4, Basic Hardboard.
   b. A208.1, Particleboard, Mat-Formed Wood.
   c. Z358.1, Emergency Eyewash and Shower Equipment.
2. American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. (ASHRAE): 110, Method of Testing Performance of Laboratory Fume Hoods.
3. Americans with Disabilities Act (ADA).
4. APA–The Engineered Wood Association (APA): Grades and Specifications.
5. Architectural Woodwork Institute, Architectural Woodwork Manufacturers Association of Canada, Woodwork Institute (AWI, AWMAC, WI): Architectural Woodwork Standards.
6. ASTM International (ASTM):
   a. A167, Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
   b. A507, Standard Specification for Drawing Alloy Steel, Sheet and Strip, Hot-Rolled and Cold-Rolled.
   c. A666, Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar.
   d. C1048, Standard Specification for Heat-Strengthened and Fully Tempered Flat Glass.
   e. D1193, Standard Test for Reagent Water.
   f. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
7. National Electrical Manufacturer's Association (NEMA):
   a. LD 3, High Pressure Decorative Laminates (HPDL).
   b. WD 1, General Color Requirements for Wiring Devices.
8. National Institute of Standards and Technology (NIST), Product Standard Section: PS 1, Structural Plywood.
9. National Fire Codes–National Fire Protection Association (NFPA):
   a. 30, Flammable and Combustible Liquids.
   b. 45, Fire Protection for Laboratories Using Chemicals.
10. Occupational Safety and Health Administration (OSHA): General Industry Standards, Section 1910.106.

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11. Scientific Equipment and Furniture Association (SEFA):
    a. SEFA 1, Recommended Practices For Laboratory Fume Hoods.
    b. SEFA 2, Recommended Practices For Installations.
    c. SEFA 8, Recommended Practices For Laboratory Grade Casework.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings: Completely describe and illustrate design features, materials, fabrication, and casework layout including rough-in details for plumbing, electrical, and ventilation connections.
    a. Key units to Contract Document designations.
    b. Provide details and dimensions not controlled by job conditions.
    c. Show required field measurements beyond manufacturer's control.
    d. Establish and maintain applicable rough-in and field dimensions.
    e. Descriptive literature and manufacturer's specifications of casework, hardware, service fixtures, and specialty items.
    f. Brochures, catalogs, installation instructions, and operations and maintenance manuals.
    g. Clearly mark with Contract Document designation each proposed item in manufacturer's literature.
    h. Coordinate Shop Drawings with other trades.
    i. Anchorage and bracing drawings and/or catalog information, as required by Section 01 88 15, Anchorage and Bracing, for loads provided in Section 01 61 00, Common Product Requirements.
2. Samples:
    a. Finished color Samples of each finish proposed by casework manufacturer.
    b. Sample unit, complete with hardware including locks, accessories, and top for Owner's inspection and 1 month's use. Unit, except top, may be used on Project.

B. Informational Submittals:

1. Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing, for loads provided in Section 01 61 00, Common Product Requirements. Submit with Action Submittal for the same item.
2. Fume hood performance test results.
3. Qualifications of manufacturer and installation lead person.

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1.03 QUALITY ASSURANCE

A. Standards:

1. Casework: Conform to AWI, AWMAC, and WI Architectural Woodwork Standards, Section 10, Premium grade, including laboratory features.
2. Fume Hoods: Conform with testing method of ASHRAE 110 and resulting instantaneous and average performance rating of 8 AM 0.1 (controls or limits loss of containment to less than 0.1 part per million "as manufactured" at release rate of 8 liters of sulfur hexafluoride per minute over the testing period) with face velocity of 100 fpm.

B. Casework Manufacturer Qualifications:

1. Reputation for doing satisfactory work on time.
2. Successful completion of comparable work.
3. Specialization in design and manufacture of plastic laminate casework or furnishings for scientific laboratories.
4. Operation of adequate size factory devoted to manufacture of plastic laminate laboratory casework or furnishings.
5. Exclusion of brokers and unauthorized representatives.
6. Minimum 5 years' experience in manufacture of quality and type of laboratory casework and furnishings specified.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Do not deliver materials to Project Site until excessive moisture is out of building for at least 10 days.

B. Store casework inside in dry and well-ventilated areas, and do not subject to extreme changes in temperature or humidity.

C. Coordinate delivery and installation with Engineer. Owner may wish to inspect items in Contractor's presence to verify condition.

PART 2 PRODUCTS

2.01 CASEWORK MANUFACTURERS

A. Plastic laminate faced casework of the following manufacturers, meeting these Specifications, may be used on this Project:

1. LSI Corp., Minneapolis, MN.
2. Nolen Products, Knoxville, TN.
3. TMI Systems, Dickinson, ND.
4. Westmark Products, Tacoma, WA.

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5. Institutional Casework, Inc., Paris, TN.
6. Kewaunee Scientific Corporation, Statesville, NC.
7. Laboratory Design and Supply, Buford, GA.

2.02 CASEWORK MATERIALS

A. Composition Board:

1. Particleboard or monolithic flakeboard.
2. Three-ply board of balanced construction.
3. Thickness: Minimum 3/4 inch.
4. Density: Minimum 45 pounds per cubic foot.
5. Moisture Content: Maximum 10 percent.
6. Made with waterproof glue.
7. ANSI A208.1, Grade M-2.

B. Plywood: APA exterior type conforming to NIST, Product Standard Section, PS 1.

1. Thickness: Minimum 3/4 inch.
2. Grade: No knots or voids present on surfaces. Use marine grade for cabinet bases.

C. Hardboard:

1. Wood fibers and resin binder molded under high pressure.
2. Thickness: Minimum 1/4 inch.
3. Premium grade.
4. Tensile Strength: 3,500 psi.
5. Shear Strength: 4,500 psi.
6. ANSI A135.4, Type II, Surface 2, Finish A, Design A.

D. Chemical-Resistant Plastic Laminate:

1. High-pressure plastic laminate for cabinet surfaces, excluding countertops.
2. Thickness: 0.034 inch plus or minus 0.005 inch.
3. NEMA LD 3, Grade HGP 30 with Grade CLS 20 backing.
4. Chemical Resistance for 16-Hour Contact Period:
    a. No effect for dilute acids, solvents, bases, indicators, biological stains, and general reagents.
    b. Only slight change of gloss or color for 48 percent hydrofluoric acid, chromic acid, 85 percent phenol, and 78 percent calcium thiocyanate.
    c. Only slight damage for 70 percent nitric acid and 96 percent sulfuric acid.

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5. Color: As shown in Interior Finish Schedule.
6. Manufacturer and Product: Wilsonart; Chemsurf.

E. Extra-High Wear Plastic Laminate:

1. High-pressure plastic laminate for Special Cabinets defined in Article Casework Fabrication of this section, excluding countertops.
2. NEMA LD 3, Grade HDM 50.
3. Thickness: 0.059 plus or minus 0.005 inch.
4. Stain Resistance: Show essentially no effect for materials 1 through 23 and moderate effect for materials 24 through 29 when tested according to NEMA LD 3.
5. Finish and Color: As shown in Interior Finish Schedule.
6. Manufacturer and Product: Wilsonart; High Wear.

F. Edge Banding:

1. Minimum 3-mm-thick polyvinyl chloride.
2. Color: Black.

G. Seismic Edges:

1. Shelves:
   a. Material: Plexiglas attached with counter sunk screws.
   b. Thickness: 3 mm.
   c. Height: 1 inch above top of each shelf.

H. Hardware:

1. Hinges: Minimum five-knuckle, hospital tip fixed pin type, dull chrome finish, four screws each leaf into faces; no edge fastening permitted.
2. Pulls: Manufacturer’s standard semiflush type of molded ABS plastic in color as shown in Interior Finish Schedule.
3. Shelf Fasteners: Metal or plastic design providing rigid and true shelf alignment.
   a. Metal: Dull chrome finish.
   b. Plastic: Match cabinet interior color.
4. Drawer Slides:
   a. Metal designed to mate with drawer slides in cabinets.
   b. Provide smooth sliding action.
   c. Load Support on Extended Drawer: 200 pounds in file drawers, 75 pounds in drawers 6 inches and less in depth, and 100 pounds in other drawers.

I. Accessories: Manufacturer’s standard catches, grommets, and other accessories and trim required to complete installation in secure and rigid manner. Finish to match other exposed hardware.

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J. Transparent Doors: Clear tempered float glass, conforming to ASTM C1048, Kind FT, Condition A, Type I, Class 1, glazing quality, 1/4 inch (6 mm) minimum thickness.

K. Adhesives: Manufacturer's standard water-resistant adhesives.

L. Countertops:

1. Epoxy Resin:
   a. Molded, modified, solid epoxy resin.
   b. Formulated to produce smooth, nonabsorbent, chemical-, heat-, and shock-resistant surface.
   c. Homogeneous in color and texture.
   d. Thickness: Minimum 1 inch.
   e. Drip groove under front edge.
   f. Integral two-piece glued backsplash for full length of adjoining walls.
   g. Color: Black.
   h. Manufacturers and Products:
      1) Durcon; Durcon Resin.
      2) Prime Industries, Inc.; Prime-Resin.

M. Backsplashes, Backsplash Returns, and Splash Curbs (SCB): Same material as adjacent countertop.

N. Drain Racks (DRK): Polypropylene pegs on epoxy resin countertop material in sizes shown on Drawings and Drain Rack Detail.

2.03 FUME HOOD FHD-1

A. Description:

1. 5-foot automatic bypass air type fume hood.
2. Hood should have an integral blower mounted directly to the top of the fume hood. Blower will be 1/2 hp, belt-driven.
3. Size: 60 inches long by 37.7 inches deep by 66 inches high exterior dimensions.
4. Fire- and chemical-resistant finish inside and out.
5. Construction: Flame-resistant molded fiberglass reinforced polyester resin interior and steel exterior.
6. Two remote service fixtures indexed for cold water and located where shown on Drawings.
7. One ground fault circuit interrupt (GFCI) electrical duplex receptacle(s) located where shown on Drawings.
8. Postless, pulldown, safety glass sash.

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9. Matching U.S. Standard 18-gauge, ASTM A507, mild steel closure panels (CPL) to close openings to within 1 inch above installed fume hood.
10. Epoxy resin dish molded countertop surface to contain spills.
11. Cup Sinks: Locate where shown on Drawings with panel vacuum breaker cold water fixture with serrated nozzle end discharging into cup sink.
12. Base cabinet fume vent (BCV) for fumes from base cabinet.
13. Acid storage and Flammable base cabinets, as shown on Drawings, provided by same manufacturer as fume hood and designed to be integrated with fume hood model. Capable of supporting minimum of 800 pounds.
14. Operation Mode: Conventional automatic bypass with bypass air varying with sash height.
15. Fixed, nonadjustable baffle.
16. Removable front and side panels, and front access panels, for access to plumbing and electrical connections.
17. Face Velocity: Design for 80 fpm with sash full open (745 cfm at 0.20-inch water column external static pressure) from remotely located motor/blower.
18. Exhaust Duct Connection: 12.8-inch inside diameter.
19. Electronic sensor, digital face velocity monitor (FVM) with audible and visible alarm for low flow conditions, flush mounted on face rail as shown on Drawings.
20. High efficiency, instant start T8 fluorescent lighting located outside hood interior and sealed behind 1/4-inch-thick safety glass vapor proof assembly with external access.
21. 120 Volt, 20 Amp: Connect light, light switch, receptacles, and FVM in accordance with local codes.
22. Color: Glacier white.

B. Manufacturer and Product: Labconco; Model No. 100500042, 9827900, 9501511, 4005200, 9851500, 9413400, 9901200, 9903200.

2.04 LABORATORY EPOXY RESIN SINK LSK-1

A. Description:

1. Double Compartment: One-piece, molded epoxy resin with coved corners and corner outlet.
2. Size: 37-1/2 inches long by 15 inches wide by 11 inches deep interior dimensions.
3. Epoxy resin sink drain outlets complete with removable strainer, stopper, and 1-1/2-inch tailpiece.

B. Manufacturer and Product: Durcon; Model No. D30D.

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2.05 LABORATORY EPOXY RESIN SAMPLE SINK LSK-2

A. Description:

1. Single Compartment: One-piece, molded epoxy resin with coved corners and corner outlet.
2. Provide for six sample taps from processes.
3. Size: 48 inches long by 15 inches wide by 11 inches deep interior dimensions.
4. Epoxy resin sink drain, outlet complete with removable strainer, stopper, and 1-1/2-inch tailpiece.

B. Manufacturers and Products:

2.06 LABORATORY CUP SINK LSK-3

A. Description:

1. Molded Epoxy or Modified Resin: Oval shape.
2. Size: 6 inches long by 3 inches wide by 4-1/2 inches deep inside dimensions.
3. 1-1/2-inch tailpiece with removable strainer.
4. Flush mounted in epoxy resin countertop.

B. Manufacturers and Products:

1. Durcon; Model No. CS4R.
2. Prime Industries; Model No. PCS4R.

2.07 SAFETY SHOWER/EYEWASH COMBINATION SSR/EWH-1

A. Description:

1. Freestanding floor model.
2. All corrosion-resisting stainless steel, including exposed-to-view piping.
3. 1-1/4-inch steel tube stanchion and floor flange.
4. Valves: Stay-open, ball type.
5. Shower: 8-inch diameter with rigid pull down to open, push up to close, triangular handle pull rod.
6. Eye/Face Wash: Aerated spray nozzles and bowl with push flag valve handles.
7. Supply and Drain: 1-1/4 inches.
8. Configure and mount in accordance with ANSI Z358.1 with showerhead bottom installed 82 inches to 96 inches above floor.
9. Alarm: Magnetically operated proximity switch.
10. Universal emergency sign.

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B. Manufacturers and Products:

1. Haws; Model No. 8330.
2. Speakman; Model No. SE-623.
3. Guardian; Model No. G1950PCC.
4. WaterSaver; Model No. SS950PCC.

2.08 LABORATORY SERVICE FIXTURES

A. General: Protect plumbing service fixtures with manufacturer's standard epoxy enamel coating applied by manufacturer's electrostatic powder coating process.

B. Air Gap LP-1

1. Drain air gap for glassware washer, flask washer, or dishwasher.
2. Plastic extension and inner cap with chrome-plated outer cap.
3. Supply locknut, washers, and installation hoses and clamps.
4. Manufacturer and Product: Delta; Model No. 2020.

C. Deck-Mounted Mixing Faucet LP-2

1. Swing gooseneck with 6-inch spread, vacuum breaker, and removable aerator.
2. Index for hot and cold water.
3. Manufacturers and Products:
   a. Chicago Faucets; Model No. 930 -CP.
   b. WaterSaver Faucet Co.; Model No. L412VB.

D. Deck-Mounted Gooseneck Faucet LP-3

1. Rigid gooseneck, vacuum breaker, and removable serrated nozzle.
2. Faucet handle position(s) as shown on Drawings.
3. Index for cold water.
4. Manufacturers and Products:
   a. Chicago Faucets; Model No. 928-CP.
   b. WaterSaver Faucet Co.; Model No. L611VB.

E. Deck-Mounted Mixing Prerinse Swing Spout LP-4

1. 23-inch riser and 36-inch spring action type flexible stainless steel hose.
2. Self-closing valve with insulated handle.
3. Adjustable valve hook, rubber bound spray head, and wall support bracket.
4. In-line vacuum breaker between head- and lever-operated valve.
5. Check valves to prevent crossflow from hot to cold water.

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6. Manufacturers and Products:
    a. Chicago Faucets; Model No. 919.
    b. WaterSaver Faucet Co.; Model No. PR411.

F. Single Pedestal Vacuum Cock LP-5

1. Turret mounted single ball value rated for vacuum.
2. Supply nipple and locknut.
3. Index for vacuum.
4. Manufacturers and Products:
    a. Chicago Faucets; Model No. 980-WSV909AGVCP.
    b. WaterSaver Faucet Co.; Model No. L4200-131WSA.
5. Series.

G. Multioutlet Assembly, Ground Fault Circuit Interrupter (GFCI) Protected LE-1

1. Two-circuit with adjacent outlets on alternated circuits.
2. Three-wire grounding receptacles configured NEMA WD 1 Type 5-20R on 12-inch centers.
3. Five-Wire: Two-phase conductors, two neutrals, and one common ground.
4. Size: 1-9/32 inches wide by 3/4 inch deep by lengths shown on Drawings.
5. Finish and Color of Raceway and Alternate Receptacles: As shown in Interior Finish Schedule.
6. Manufacturer and Product: Legrand; Plugmold 2000.

2.09 FURNISHINGS AND EQUIPMENT

A. Adjustable Chair/Stool, ACS.

B. Lab Water System, LWS-1:

1. Wall-mounted fully automatic system.
2. Produces a minimum of 3 liters of ASTM D1193 Type I organic free water, TOC less than 10 micograms per liter, per hour from feed tap water.
3. Finished resistivity of greater than 16 megohm-cm.
4. Integral storage tanks of a minimum of 6 liters.
5. Plumb output of Lab Water System to Lab Water System Storage Tank.

C. Lab Water System, Storage Tank, LWS-2

1. Polyethylene storage tank.
2. Minimum 30 liter capacity.
3. Route output of Lab Water System Storage Tank to LSK-1.

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D. Paper Towel Dispenser, PTD:

1. Surface-mounted, 22-gauge Type 304 (18-8) stainless steel unit with refill indicator slot.
2. Capacity: 400 C-fold towels.
3. Size: Approximately 15 inches high by 11 inches wide by 4 inches deep exterior dimensions.
4. Tumbler lock and hinged opening.
5. Finish: Satin.
6. Manufacturers and Products:
    a. Bradley; Model No. 250-15.
    b. Bobrick; Model No. B-262.

E. Refrigerator/Freezer, Laboratory, RFR:

1. Upright model with single door.
2. Capacity: Minimum 12.6-cubic feet.
3. Size: 29 inches wide by 65 inches high by 30 inches deep exterior dimensions.
4. Door Swing: Left opening (right hinge) as shown on Drawings.
5. Designed to comply with NFPA and OSHA for flammable storage.
6. Three adjustable shelves.
7. White enamel exterior.
8. 120-volt.
9. Lockable doors.
10. Manufacturers and Products:
    a. VWR Scientific; Model No. 97055-722.
    b. Fisher Products; Model No. 13-986-151B.

F. Safety Eyewear Holder, SEH:

1. Hold safety eyewear (glasses or goggles).
2. Capacity: Eight pairs of safety spectacles.
3. Size: 6 inches deep by 9 inches wide by 6 inches high exterior dimensions.
4. Clear acrylic construction.
5. Manufacturers and Products:
    a. Fisher Scientific; Model No. 19-003-249.
    b. VWR Scientific; Model No. 56606-554.

G. Washer, Flask, FWR:

1. Under-counter unit with stainless steel exterior specifically designed for laboratory flasks up to 2,000-ml capacity.
2. Size: 24 inches wide by 26.4 inches deep by 34.3 inches high exterior dimensions.
3. Stainless steel door with four leveling feet.

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4. Safety glass viewing window with interior light.
5. Dispensers: Detergent and rinse solution.
6. Stainless steel constructed interior.
7. Control panel with five factory preset and two user set microprocessor programs covering wash, steam, standard rinse, purified water rinse, and dry cycles.
8. Safety lock, cancel, and drain functions.
9. 20 degrees F above inlet temperature washing cycles with two approximate 700-watt booster heaters.
10. Room temperature purified water rinse cycles (deionized or reverse osmosis).
11. Stainless steel spindle rack using 34 detachable spindles, two sizes of spindle clips, multi-pin insert, and two sizes of glassware holders.
12. Steam generator, purified water pump, and vacuum drying manifold.
13. Standard multi-pin insert and 4-inch and 6-inch glassware holder (two each).
14. Accessories: Adjustable height top rack with two hub adapters, extra multi-pin insert, eight pipet insert, 14 pipet insert, extra 4-inch and 6-inch glassware holders, and utensil basket with retainer top.
15. 1-1/2-inch vent trap and drain air gap located at adjacent sink.
16. 3/8-inch IPS inlet fitting for hot water tap connection providing minimum 1-1/4 gallons per minute flow.
17. 3/4-inch ID flex hose connection for purified water providing minimum 1-1/2 gallons per minute flow.
18. 120-volt, 16-amp.
19. Manufacturer and Product: Labconco; Model No. 44203-10.

H. White Board, WBD:

1. Materials: Stretcher level sheet steel facing, 28-gauge minimum; plywood, particle board, or hardboard backing; anodized extruded aluminum frame and tray.
2. Composition: Face sheet bonderized and surfaced to accept watercolor and semi-permanent writing inks with selective erasability; Class 1 Fire Hazard Classification with flame spread of 25 or less when tested in accordance with ASTM E84-91a; bonded to plywood, hardboard, or particle board backing.
3. Finish and Color: White porcelain enamel semigloss writing surface finish impervious to cracking, checking, chipping, and peeling. Extruded aluminum frame and tray clear anodize finish.
4. Size: 4 feet by 2-1/2 feet.
5. Accessories: Twelve watercolor markers, six black and six assorted colors compatible with writing surface; cleaners, towels, magnetic strips, and instruction booklet.

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6. Manufacturers:
    a. Alliancewall Corp.
    b. Best-Rite Chalkboard Co.
    c. Carolina Chalkboard Co.
    d. Claridge Products & Equipment, Inc.
    e. Greensteel, Inc.
    f. Weber Costello Co.

I. Ice Maker, ICM:

1. Undercounter ice maker capable of producing 50 pounds or more of ice in a 24 hour timeframe.
2. Storage capacity for 20 pounds or more of ice.

2.10 CASEWORK FABRICATION

A. Construct casework of plywood or composition board core, at manufacturer's option, covered with laminated plastic sheets on both surfaces.

B. Furnish manufacturer's standard modular units conforming as closely as possible to dimensions and configurations shown on Drawings, or specially made casework units where standard sized units do not conform to dimensions and configurations shown on Drawings.

C. Construct casework with face screwed fasteners. Do not depend on mechanical fastening, gluing, or screwing of core edges for strength.

D. Excluding countertops, fabricate cabinet surfaces (fronts, backs, sides, tops, bottoms, shelves, doors, drawer fronts, bases, and fillers) with minimum 3/4-inch-thick plywood or composition board covered with chemical-resistant plastic laminate on both sides bonded by polyester resin at high pressure and temperature. Seal and protect cabinet and drawer surfaces from water intrusion.

E. Radius exposed corners at least 1/4 inch.

F. Protect edges from water intrusion including edges not exposed to view, e.g. resting on base, sitting on floor, standing behind cabinet. Install vinyl edges on exposed edges of cabinets, doors, and drawers. Locate joints in vinyl edges where least noticeable. Bond under pressure with waterproof hot melt glue and finish with smooth, radiused edges, and corners.

G. Cabinet Bases:

1. Design and construct separately from side and back panels to support cabinets rigidly in true alignment.
2. Material: Marine grade exterior plywood.

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3. Height: 4 inches.
4. Install adjustable leveling feet at each corner and at intermediate points necessary for rigid support.

H. Countertops: Self-edged type.

I. Backsplashes and Splash Curbs: Field glued.

J. Cabinet Fronts: Flush design with no projecting edges.

K. Access Panels: Removable units opening to pipe space behind cases at knee spaces, balance tables, ends of islands and peninsulas, and elsewhere for access.

L. Sliding Glass Doors: Frameless type in wall-mounted or double-sided island or peninsula-mounted cases. Framed type for tall storage cabinets and base cabinets.

M. Color: Countertops, fronts, trim, and other exposed surfaces as shown in Interior Finish Schedule.

N. Seismic Edges: Accessible sides of open shelves including wall units located above countertop height and on adjustable shelves only of closed, sliding glass door units at any height.

O. Wood Drawers: Construct in accordance with AWI, AWMAC, WI Architectural Woodwork Standards Premium grade including laboratory features.

PART 3 EXECUTION

3.01 INSPECTION AND PREPARATION

A. Make field measurements of items or conditions affecting casework, equipment, and furnishings.

B. Examine grounds and supports of casework to assure adequate anchorage, free of foreign material, moisture, and unevenness that would prevent quality casework installation.

C. Verify that ventilation outlets, service connections, and supports are correct and in proper location.

D. Identify and correct defects before proceeding with installation.

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3.02 INSTALLATION

A. Use proper type of anchoring devices for materials encountered. Accurately place anchor bolts using templates furnished by equipment manufacturer and as specified in Section 05 50 00, Metal Fabrications.

B. Install in accordance with manufacturer's instructions.

C. Except where noted, install in new and ready-to-use condition.

D. Cut, fit, patch, and provide support where required for proper and complete installation.

E. Casework:

1. Secure casework in place in true alignment, level, and plumb. Secure casework units to cleats anchored to building structure or wall framing. Install wall-hung cabinets to firmly and rigidly support cabinet weight plus normally expected cabinet content weight.
2. Fasten together adjoining cabinets in an assembly joined at top and bottom of front and back with bolts placed inconspicuously inside cabinets.
3. Close exposed-to-view openings larger than joints with filler of same material and finish as adjacent casework. Secure filler to casework with concealed screws. Use minimum width and number of fillers consistent with need. Except where shown on Drawings, do not use filler panels (FPL) exceeding 6-inch width.
4. Install cabinet front face 3 inches in front of cabinet base face to provide toe space.
5. Anchor shelf fasteners with screws when seismic edges used. Position shelves as directed by Owner.

F. Countertops:

1. Install standing height countertop's working surface 37 inches above finished floor. Install desk height countertop's working surface 31 inches above finished floor.
2. Install level to within 1/16 inch in 10 feet and in largest possible increments.
3. Where not supported by base cabinets or other furnishings, use brackets or other support on minimum 3-foot centers.
4. Make joints with manufacturer-provided cement containing same color and chemical-resistance characteristics as top material. Leave joints smooth and in same plane as top.

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G. Laboratory Sinks and Service Fixtures:

1. Install in countertops and cases in manner recommended by manufacturer.
2. Take care to avoid scratches and other damage to cases and countertops.
3. Install ready for connection of services.

H. Furnishings:

1. Provide equipment with connection terminals for plumbing, gas, steam, electrical, ventilation, and refrigeration service connections where required.
2. Where items are supplied without line cords, furnish line cord and plug compatible with electrical service and available outlets.

3.03 FUME HOOD TESTING

A. Test installed fume hoods for flow visualization, both local and large-volume challenges, and face velocity in conformance with test methods of current ASHRAE 110 and resulting instantaneous and average performance rating of 4 AI 0.1 (controls or limits loss of containment to less than 0.1 part per million “as installed” at release rate of 4 liters of sulfur hexafluoride per minute over the testing period) with face velocity of 100 fpm.

B. Conduct testing after HVAC balancing as required by Section 23 05 93, Testing, Adjusting, and Balancing for HVAC, has been completed.

C. Replace fume hood for failure to meet flow visualization challenges, to maintain average face velocity within 80 plus or minus 10 fpm, or to attain individual face velocity readings within plus or minus 10 fpm of the average.

3.04 ADJUSTING AND CLEANING

A. Adjust hardware and leave in smooth, easy condition. Remove protective maskings. Clean surfaces ready for use. Restore stained or discolored finishes or replace item.

B. Inspect, adjust, clean, and test service fixtures to assure intended operation.

END OF SECTION

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SECTION 12 49 00
ROLLER SHADES

PART 1 GENERAL

1.01 SUBMITTALS

A. Product Data:

1. Manufacturer's data sheets on each product clearly marked for products used on this Project, including:
   a. Preparation instructions and recommendations.
   b. Styles, material descriptions, dimensions of individual components, profiles, features, finishes, and operating instructions.
   c. Storage and handling requirements and recommendations.
   d. Mounting details and installation methods.
   e. Typical wiring diagrams.

B. Shop Drawings: Plans, elevations, sections, product details, installation details, operational clearances, and relationship to adjacent work.

C. Window Treatment Schedule: For all roller shades. Use same room designations as indicated on Drawings and include opening sizes and key to typical mounting details.

D. Color Samples: Provide three each, shade cloth sample and aluminum finish sample as specified.

E. Maintenance Data: Methods for maintaining roller shades, precautions regarding cleaning materials and methods, instructions for operating hardware and controls.

1.02 QUALITY ASSURANCE

A. Manufacturer Qualifications: Obtain roller shades through one source from a single manufacturer with a minimum of 5 years' experience in manufacturing products comparable to those specified in this section.

B. Installer Qualifications: Installer trained and certified by the manufacturer with a minimum of 3 years' experience in installing products comparable to those specified in this section.

C. Fire-Test-Response Characteristics: Passes NFPA 701 small and large-scale vertical burn.

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D. Anti-Microbial Characteristics: 'No Growth' in accordance with ASTM G21 results for fungi ATCC 9642, ATCC 9644, ATCC 9645.

1.03 DELIVERY, STORAGE, AND HANDLING

A. Deliver shades in factory-labeled packages, marked with manufacturer and product name, fire-test-response characteristics, and location of installation using same room designations indicated on Drawings and in the Window Treatment Schedule.

1.04 PROJECT CONDITIONS

A. Environmental Limitations: Install roller shades after finish work including painting is complete and ambient temperature and humidity conditions are maintained at the levels indicated for Project when occupied for its intended use.

PART 2 PRODUCTS

2.01 APPLICATIONS

A. Roller Shade Scope:

1. Shade Types: Manual operating, chain drive, roller shades in exterior windows as scheduled in the Window Schedule on the Drawings.

2.02 SHADE CLOTH

A. Visually Transparent Single-Fabric Shade Cloth: Single thickness non-raveling 0.030-inch thick vinyl fabric, woven from 0.018-inch diameter extruded vinyl yarn consisting of 21 percent polyester and 79 percent reinforced vinyl, 2 percent to 3 percent open weave.

1. Color: Manufacturer’s standard light beige, (MechoShade 1002 Beige).
2. Manufacturer and Product:
    a. MechoShade Systems, Inc.; ThermoVeil, 1000 Series.
    b. Or approved equal.

2.03 SHADE BAND

A. Construction of shade band includes the fabric, the hem weight, hem-pocket, shade roller tube, and the attachment of the shade band to the roller tube. Sewn hems and open hem pockets are not acceptable.

2.04 SHADE FABRICATION

A. Fabricate units to completely fill openings from head to sill and jamb-to-jamb, unless specifically indicated otherwise.

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B. Fabricate shade cloth to hang flat without buckling or distortion. Fabricate with heat-sealed trimmed edges to hang straight without curling or raveling. Fabricate unguided shade cloth to roll true and straight without shifting sideways more than 1/8-inch (3.18 mm) in either direction per 8 feet (2438 mm) of shade height due to warp distortion or weave design. Fabricate hem using bottom hem weights.

2.05 ACCESSORIES

A. Fascia:

1. Continuous removable extruded aluminum fascia that attaches to shade mounting brackets without the use of adhesives, magnetic strips, or exposed fasteners.
2. Fascia shall be able to be installed across two or more shade bands in one piece.
3. Fascia shall fully conceal brackets, shade roller and fabric on the tube.
4. Provide bracket/fascia end caps where mounting conditions expose outside of roller shade brackets.
5. Notching of Fascia for manual chain not acceptable.

PART 3 EXECUTION

3.01 EXAMINATION

A. Do not begin installation until substrates have been properly prepared.

B. Notify Engineer of unsatisfactory preparation before proceeding.

3.02 PREPARATION

A. Clean surfaces thoroughly prior to installation.

B. Prepare surfaces using the methods recommended by the manufacturer for achieving the best result for the substrate under the project conditions.

3.03 INSTALLATION

A. Install roller shades level, plumb, square, and true according to manufacturer's written instructions, and located so shade band is not closer than 2 inches to interior face of glass. Allow proper clearances for window operation hardware. Provide an individual shade for each window pane.

B. Adjust and balance roller shades to operate smoothly, easily, safely, and free from binding or malfunction throughout entire operational range.

C. Clean roller shade surfaces after installation, according to manufacturer's written instructions.

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3.04 PROTECTION

A. Protect installed products until completion of project.

B. Touch-up, repair or replace damaged products before Substantial Completion.

3.05 INSTALLATION SCHEDULE

A. Install roller shades where indicated in the Window Schedule on Drawings.

END OF SECTION

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SECTION 13 34 19
METAL BUILDING SYSTEMS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Architectural Manufacturers' Association (AAMA):
   a. 605, Voluntary Specification for High Performance Organic Coatings on Architectural Extrusions and Panels.
2. American Institute of Steel Construction (AISC):
   a. 360, Specification for Structural Steel Buildings.
   b. RCSC Specification for Structural Joints Using ASTM A325 or A490 Bolts.
   c. Design Guide 3: Serviceability Design Considerations for Steel Buildings.
3. American Iron and Steel Institute (AISI): Specification for the Design of Cold-Formed Steel Structural Members.
4. American Welding Society (AWS): D1.1/D1.1M, Structural Welding Code - Steel.
5. ASTM International (ASTM):
   a. A36/A36M, Standard Specification for Carbon Structural Steel.
   b. A307, Standard Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength.
   c. A325, Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength.
   d. A490/A490M, Standard Specification for Structural Bolts, Alloy Steel, Heat-Treated, 150 ksi Minimum Tensile Strength.
   e. A529/A529M, Standard Specification for High-Strength Carbon-Manganese Steel of Structural Quality.
   f. A572/A572M, Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel.
   g. A653/A653M, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
   h. A792/A792M, Standard Specification for Steel Sheet, 55% Aluminum-Zinc Alloy-Coated by the Hot-Dip Process.
   i. A992/A992M, Standard Specification for Steel for Structural Shapes.
   j. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
   k. E96/E96M, Standard Test Methods for Water Vapor Transmission of Materials.

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l. E1514, Standard Specification for Structural Standing Seam Steel Roof Panel Systems.
m. F1554, Standard Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength.

6. International Code Council (ICC): International Building Code (IBC) and International Energy Conservation Code (IECC).
7. Metal Building Manufacturer's Association (MBMA): Metal Building Systems Manual.
8. UL: 580, Tests for Uplift Resistance of Roof Assemblies.

1.02 SYSTEM DESCRIPTION

A. Complete building package using manufacturer's standard components and components specified in other sections.

B. Primary Framing System: Clear span rigid frame. Provide intermediate columns only where shown on the Drawings.

C. Secondary Framing System:

1. Sidewall Girts: Provide inset girts with flush column offset.
2. Endwall Girts: Provide manufacturer's standard offset to steel line.
3. Roof Purlins: Provide manufacturer's standard (top set) purlins.

D. Lateral Support System in Longitudinal Direction: Cross bracing and portal frames where located on the Drawings.

E. Include: Insulated metal wall and roof panels and metal trim as specified herein.

F. Include: Doors, windows, louvers, and other accessories as specified in other sections.

1.03 DESIGN REQUIREMENTS

A. Applicable Building Code: The 2015 International Building Code (IBC), as amended by the State of New Mexico and local agencies.

B. Applicable Energy Code: The 2015 International Energy Conservation Code (IECC), as amended by the State of New Mexico and local agencies.

C. Refer to design criteria on the Drawings including General Structural Notes and individual facility plans.

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D. Snow Load:

1. Ground Snow Load (Pg): **[A:]** pounds per square foot.
2. Exposure Coefficient (Ce): **[B: .]**
3. Thermal Factor (Ce): **[C: .]**
4. Importance Factor (I): **[D: 1.00.] [E: .]**
5. **[F: Drifting: As shown on Drawings.]**

E. Minimum Roof Live Load: **[A: 20] [B:]** pounds per square foot.

F. Building system dead load.

G. Mechanical and Electrical Equipment Loads:

1. Purlins and Secondary Framing: As indicated on Drawings, minimum **[A: 10] [B:]** pounds per square foot collateral load.
2. Primary Frames: As indicated on Drawings, minimum **[C: 5] [D:]** pounds per square foot collateral load.

H. Special Equipment Loads, as shown on Drawings:

1. **Facility 300 Process Building, 3 Monorails:] [D:]-ton capacity. Design building framing to support monorails from roof framing.**
2. **[E: .]]**

I. Wind Load:

1. Ultimate Design Wind Speed: **[A:]** miles per hour.
2. Nominal Design Wind Speed: **[B:]** miles per hour.
3. Risk Category: **[C: .]**
4. Exposure Category (Ce): **[D: .]**
5. Internal Pressure Coefficient: **[E: .]**

J. Earthquake Load:

1. Risk Category: **[A: .]**
2. Soil Site Class: **[B: .]**
3. Seismic Parameters:
   a. S_S: **[C: .]**
   b. S_1: **[D: .]**
   c. S_{DS}: **[E: .]**
   d. S_{D1}: **[F: .]**
4. Seismic Design Category: **[G: .]**
5. Importance Factor: **[H: 1.00.] [I: 1.25.] [J: 1.50.]**

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K. Deflection Criteria:

1. In accordance with AISC Design Guide 3 recommendations. Conformance is required to deflection criteria as stated in the Appendix.
2. Applies to primary and secondary framing members, bracing members, roof panels, and wall cladding.

L. Design Standards:

1. AISC 360.
2. AISC RCSC Specification for Structural Joints Using ASTM A325 or ASTM A490 Bolts.
3. AISI Specification for the Design of Cold-Formed Steel Structural Members.
4. AWS D1.1/D1.1M.

M. Consider prying action of bolts for bolted moment-resistant connections in primary framing.

N. Design column bases as pinned, unless specifically indicated otherwise.

1.04 CONTRACTOR/METAL BUILDING MANUFACTURER COORDINATION

A. Submit metal building shop drawings and obtain approval prior to forming foundation concrete or fabricating foundation reinforcing steel. Confirm size of concrete column pilasters for steel column baseplates and its associated anchor bolt template.

B. Verify interface of building components with foundation and coordinate required foundation revisions with Engineer.

1.05 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Manufacturer’s literature and technical data.
   b. Drawings Stamped by Designer:
      1) Drawings shall be specifically prepared for this Project.
      2) Mark out details that do not apply to Project.
      3) Show design load criteria, material specifications for framing members and connections, roof framing plan with dimensions and member sizes, baseplate details showing anchor bolt size and bolt layout, elevations of wall framing and bracing, instructions for temporary bracing, framing around roof and wall openings, details for joining and

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sealing of roof panels and wall cladding, and sections and details for all components and accessories.

c. Anchorage and bracing drawings and/or catalog information, as required by Section 01 88 15, Anchorage and Bracing, for loads provided in Section 01 61 00, Common Product Requirements.

d. Structural Steel Galvanizing: Provide name of coating company and location.

2. Samples: Provide 3 each, Minimum 2-inch by 3-inch metal for review and approval of colors scheduled on the Drawings..

B. Informational Submittals:

1. Structural Calculations Stamped by Designer:
   a. Complete analysis and design of structural components and connections in accordance with design requirements indicated.
   b. Summary of building column reactions to foundation level for load cases.
   c. Mark out calculations that do not apply to Project.
2. Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing, for loads provided in Section 01 61 00, Common Product Requirements. Submit with Action Submittal for the same item.
3. Manufacturer's written instructions for shipping, handling, storage, protection, and erection or installation of building and components.
4. Manufacturer: IAS Quality Certification: IAS certificate showing name and address of manufacturer, effective date, and category of certification.
5. Erector:
   a. IAS Quality Certification: IAS certificate showing name and address of erector, effective date, and category of certification, or, in lieu of IAS certification, documentation of past 5 years' experience record to include project name, location, date of completion, building manufacturer, and name and phone number of Owner's contact person.
   b. Certification of approval by manufacturer.
6. Manufacturer's Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers' Field Services.

1.06 QUALITY ASSURANCE

A. Qualifications:

1. Designer: Registered professional engineer valid in same state as Project.
2. Manufacturer: IAS Quality Certification: Metal Building Systems (MB).

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3. Erector:
    a. IAS Quality Certification as Certified Steel Erector (CSE), or 5 years of experience in erection of metal building systems in lieu of IAS certification.
    b. Approval by manufacturer.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Protect building components and accessories from corrosion, deformation, and other damage during delivery, storage, and handling.

B. Deliver to Site with parts individually tagged.

C. Store on wood blocking or pallets, flat and off ground, to keep clean and to prevent damage or permanent distortion. Support bundles so there is no danger of tipping, sliding, rolling, shifting, or material damage. Cover with tarpaulins or other suitable weathertight ventilated covering.

D. Protect finish of metal panels by application of removable plastic film or other suitable material placed between panels. Do not allow panels to come in contact with other material that would result in scratching, denting, staining or other damage to panel finish.

1.08 SPECIAL GUARANTEE

A. Furnish manufacturer’s extended guarantee or warranty, with Owner named as beneficiary, in writing, as special guarantee. Special guarantee shall provide for correction, or at the option of Owner, removal and replacement of Work specified in this Specification section found defective during a minimum period of 20 years and as stated below after date of Substantial Completion. Duties and obligations for correction or removal and replacement of defective Work as specified in the General Conditions.

B. Conditions:

1. Finish on metal roof, wall panels, flashing, and trim will not chalk, crack, check, blister, peel, flake, chip, or lose adhesion for 20 years.
2. Non-prorated, full system Guarantee: Roofing will remain weathertight for 20 years.

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PART 2 PRODUCTS

2.01 BUILDING SYSTEM MANUFACTURERS

A. Products manufactured or supplied by the following, and meeting these Specifications, may be used on this Project:

1. Butler Manufacturing Co., Kansas City, MO.
2. Nucor Building Systems, Brigham City, UT.
3. Varco-Pruden Buildings, Memphis, TN.

2.02 COMPONENTS

A. Structural Framing and Bracing:

1. Primary Framing: ASTM A36/A36M, ASTM A529/A529M, ASTM A572/A572M, or ASTM A992 with 3/16-inch minimum thickness; G60 Galvanized coating and minimum design thickness equal to 0.0346 inch.
2. Secondary Framing: Steel for cold-formed galvanized channel and z-sections shall be ASTM A653/A653M, Structural Steel (SS) Grade 33 or High-Strength Low-Alloy Steel (HSLAS) Grade 50 Type A or B, with G60 galvanized coating and minimum design thickness equal to 0.0346 inch.
3. Bracing:
   a. ASTM A36/A36M or ASTM F1554, Grade 36, for threaded rod, or ASTM A36/A36M for rolled shapes.
   b. Do not use wire rope or cable for permanent bracing.
   c. G60 Galvanized coating and minimum design thickness equal to 0.0346 inch.
4. Bolted Connections:
   a. Primary Framing: ASTM A325 or ASTM A490/A490M high-strength bolted connections. G60 Galvanized coating and minimum design thickness equal to 0.0346 inch.
   b. Secondary Framing: ASTM A307 or ASTM A325. G60 Galvanized coating and minimum design thickness equal to 0.0346 inch.

B. Insulated Metal Roofing Panels:

1. Materials and Configuration: Factory-assembled insulated preformed metal panels with manufacturer’s standard concealed fasteners, tongue and groove interlock and standing seam system.
   a. Core: Insulating polyisocyanurate foam bonded to metal face sheets.
   b. Thickness: As required for thermal value specified.

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c. Thermal Value: Minimum R-Value of 30.
d. Width: Manufacturer's standard width, 42 inch maximum.
e. Interior and Exterior Skin: 26-gauge, embossed sheet metal panels with 2 inch high standing seams meeting ASTM A792/A792M, Grade 50, minimum.
f. Exterior Finish: Factory-applied, 70 percent Fluoropolymer coating, dry film thickness of 1.0 mil including primer, in color shown in the Exterior Finish Schedule on Drawings.
1) Provide Cool Roof with Solar Reflectance Index (SRI) equal to or greater than 29.
g. Interior Finish: Factory applied polyester, DFT 1.0 mil minimum, color White.

2. Insulated Roof Panel System:
a. Panels shall be one piece from eave to ridge (except where specifically shown with horizontal joints), with concealed anchor clips and fasteners to purlins to allow for thermal movement over 120-degree ambient temperature range.
b. The side joint shall consist of a 2-inch vertical sidelap, mechanically seamed, with fasteners and thermally broken attachment clip completely concealed within the side joint.
c. Tested and certified to meet UL 580, Class 90 wind uplift rating.
d. Manufacturer and Product:
1) Kingspan; KingZip.
2) Metl Span; CFR.
3) AWIP; SR-2.

C. Insulated Metal Wall Panels:

1. Materials and Configuration:
a. Factory-assembled insulated preformed metal panels with manufacturer's standard concealed fasteners, and gasketed seam system of double tongue and groove interlocking joint.
b. Core: Insulating polyisocyanurate foam bonded to metal face sheets.
c. Thickness: As required for thermal value specified.
d. Thermal Value: Minimum R-Value of 20.
e. Width: Manufacturer's standard width, 42 inch maximum.
f. Interior and Exterior Skin: 24 gauge exterior and 26 gauge interior, adobe embossed, sheet metal panels meeting ASTM A792/A792M, Grade 50, minimum.
g. Exterior Finish: Factory-applied, 70 percent Fluoropolymer coating, dry film thickness of 1.0 mil including primer, in color shown in the Exterior Finish Schedule on Drawings.
h. Interior Finish: Factory applied polyester, DFT 1.0 mil minimum, color White.

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2. Insulated Wall Panel System:
   a. One piece from eave to sill, with base trim at sill.
   b. Sidelaps: Double interlocking joint with concealed fasteners.
   c. Manufacturer and Product:
      1) Kingspan; 300A Azteco
      2) Metl Span; Santa Fe.
      3) AWIP; HE 40A Adobe Texture.

D. Fire-Rated Insulated Metal Wall Panels:

1. Same as Insulated Metal Wall Panels specified above except:
   a. Core: Mineral fiber composite core with 2-hour fire rating; meets UL and NFPA Fire Resistance specifications.
   b. Width: As required to meet fire-rating and thermal requirements.
   c. Manufacturer and Product:
      1) Kingspan; MF Fire Rated TF, Azteco.
      2) Metl Span; ThermalSafe.
      3) AWIP; HE42MF, Adobe Texture.

2.03 ACCESSORIES

A. Hollow Metal Doors, Frames, and Hardware: As specified in Section 08 11 01, Steel Door Assemblies.

B. Overhead Doors: As specified in Section 08 30 00, Specialty Doors.

C. Translucent Wall Panels: As specified in Section 08 45 00, Translucent Wall Panels.

D. Sealant: As specified in Section 07 90 00, Sealant.

E. Roof Accessories: As specified in Section 07 70 00, Roof Specialties and Accessories.

F. Trim: Factory-formed and factory-painted ridge cap, rake trim, simple eave trim, panel side trim, corner trim, door trim, and other trim as necessary.

G. Gutter Fascia and Downspouts:

1. Material: ASTM A653/A653M, 26-gauge galvanized steel.
2. Gutter Fascia:
   a. Prefinish to match roof panels.
   b. Furnish hangers with factory-applied paint.
3. Preformed End and Corner Closures: Furnish to match configuration of gable fascia.

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4. Downspouts:
    a. Configuration: Nominal 4-inch corrugated rectangular box with minimum 11 square inches of cross section area.
    b. Factory finish to match wall panels.

H. Miscellaneous: Furnish fasteners, metal-backed neoprene washers, weatherstripping, sealants, roof curbs, gaskets, and other items as required for a complete installation.

2.04 FABRICATION

A. Factory Fabricate: To manufacturer's written standards, MBMA Metal Building Systems Manual, and AISC Specification for Structural Steel Buildings.

B. Building Parts: Accurate and true to dimension to facilitate building erection without cutting, fitting, or other alterations.

C. Welded Connections: In accordance with AWS D1.1/D1.1M.

D. Shop Primer for Structural Steel Framing: Not used, galvanized finish is exposed.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine supporting concrete foundation and anchor bolt placement for compliance with requirements for installation tolerances and other conditions affecting performance of metal building.

3.02 BUILDING ERECTION

A. Erect building system in accordance with manufacturer's standards and instructions.

B. Provide temporary bracing in accordance with MBMA standards and as required for safe installation.

C. Structural Framing:

1. Do not field cut or alter primary or secondary framing members.
2. Installation and Tolerances: In accordance with MBMA Metal Building Systems Manual.

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D. Roof and Wall Panels:

1. Field cutting of panels by torch is not permitted.
2. Attach panels to structural supports to maintain a weathertight seal while allowing for thermal and structural movement.
    a. Install exposed fasteners in true vertical and horizontal alignment.
    b. Field seam side laps of standing seam roof panels using electrically operated seaming machine.
    c. Use proper tools to install screw fasteners to compress neoprene washer without damaging washer or stripping metal.
3. Install manufacturer's standard joint sealants, gaskets, and closure strips as required for weathertight installation.
    a. Provide continuous Air Barrier at exterior envelope as required by the IECC.
4. Field Cutting and Patching: Perform in manner not to impair appearance, weathertightness, or structural capacity of panel system.
5. Fire-Rated Wall Panels:
    a. Install as recommended by panel manufacturer for hourly rating shown.
    b. Fill or close joints, panel penetrations, gaps at head and sill, and other openings as required to maintain hourly rating for entire wall area.
    c. Provide accessories and trim for flush and smooth transition to adjacent, non-rated panels.

3.03 REPAIR, CLEANING, AND PAINTING

A. Immediately following erection, remove unused material, screws, fasteners, and other debris from completed installation. Use caution in removing metal cuttings from surface of prefinished metal panels.

B. Replace damaged, dented, buckled, or discolored metal panels.

C. Repair damaged painted and galvanized surfaces as specified in Section 09 90 00, Painting and Coating.

3.04 FIELD QUALITY CONTROL

A. **[A: Special inspection will be provided by Owner where indicated on Drawings.]**

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3.05 MANUFACTURER'S SERVICES

A. Provide manufacturer's representative at Site in accordance with Section 01 43 33, Manufacturers' Field Services, for installation assistance, inspection, and certification of proper installation.

END OF SECTION

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SECTION 21 13 13
WET-PIPE SPRINKLER SYSTEMS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. National Fire Protection Association (NFPA):
   a. 13, Installation of Sprinkler Systems.
   b. 14, Installation of Standpipe and Hose Systems.
   c. 25, Standard For the Inspections, Testing, and Maintenance of Water Based Fire Protection Systems.
   d. 70, National Electrical Code (NEC).
   e. 1963, Standard for Fire Hose Connections.
2. U.S. Code of Federal Regulations (CFR).

1.02 DEFINITIONS

A. High-Pressure Sprinkler Piping: Wet-pipe sprinkler system piping designed to operate at working pressure higher than standard 175 psig, but not higher than 250 psig.

B. Standard-Pressure Sprinkler Piping: Wet-pipe sprinkler system piping designed to operate at working pressure of 175 psig maximum.

C. Wet-Pipe Sprinkler System: Automatic sprinklers are attached to piping containing water and that is connected to water supply through alarm valve. Water discharges immediately from sprinklers when they are opened. Sprinklers open when heat melts fusible link or destroys frangible device.

D. Abbreviations:

1. American National Taper Pipe Thread (NPT).
2. Authority having jurisdiction (AHJ).
3. Hertz (Hz).
4. Pounds per square inch, gauge (psig).
5. Single-pole, double-throw (SPDT).
6. Volts alternating current (V ac).
7. Volts direct current (V dc).

1.03 DESIGN REQUIREMENTS

A. Provide design criteria and area densities for the automatic sprinkler systems as indicated on Drawings.

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B. Provide sprinkler systems, including seismic bracing, designed and installed in accordance with NFPA 13.

C. Hydraulically design the systems. Submit calculations to verify that, at minimum, densities indicated on Drawings are met.

D. Base hydraulic calculations on water flow tests conducted and recorded at or near the proposed system tie-in point.

E. Contract Drawings are provided for general layout of the sprinkler system. Contractor design responsibility includes determining exact layout and dimensions of the system. Clearly identify deviations from Drawings or Specifications in the Shop Drawing submittal.

1.04 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Drawings for wet-pipe sprinkler systems; include plans, elevations, sections, details, and attachments to other work.
   b. Product Data: For pipe, fittings, valves, sprinklers and all other attachments and components needed to provide a complete and compliant installation. For electrical/alarm components include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
   c. Contractor-Design Submittal: Sprinkler system design; include analysis data signed and sealed by qualified professional engineer. Submit for approval by Owner's insurance underwriter and the fire marshal prior to the start of construction.
   d. Coordination Drawings: Sprinkler systems, drawn to scale, illustrating the coordination of the sprinkler system with:
      1) Domestic water piping.
      2) Compressed air piping.
      3) HVAC hydronic piping and duct work.
      4) Items penetrating finished ceiling, include the following:
         a) Lighting fixtures.
         b) Air outlets and inlets.

B. Informational Submittals:

1. Qualification Data: Qualified installer, design technician, and professional engineer.
2. Approved Sprinkler Piping Drawings: Working plans, prepared according to NFPA 13, approved by authorities having jurisdiction, including hydraulic calculations if applicable.
3. Welding certificates.

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4. Manufacturer's printed installation instructions.
5. Fire hydrant flow test report.
6. Field test reports and certificates.
7. Field quality control reports.
8. Operation and Maintenance Data as specified in Section 01 78 23, Operation and Maintenance Data.

1.05 QUALITY ASSURANCE

A. Comply with the applicable Fire Prevention Code, building codes, and government regulations, and requirements of the Owner's insurance underwriter.

B. Provide approvals, permits, and required inspections.

C. Provide materials and equipment UL listed and in compliance with applicable NFPA standards and fire marshal's requirements. Submit documentation that the specific items furnished under this section for this Project conform to such requirements.

D. Welding Qualifications: Refer to NFPA 13 for qualifications and restrictions.

E. Preinstallation Meeting:

1. In accordance with Section 01 31 19, Project Meetings.
2. Convene minimum 1 week(s) prior to commencing work of this section.

1.06 QUALIFICATIONS

A. Provide layout drawings for fire protection systems prepared by or under the supervision of a NICET Fire Protection Engineering Technician, Level 3 or Level 4, subfield of Fire Protection Engineering Water-Based Systems Layout or as otherwise permitted by State or local Statute. If required by State or local Statute, provide Drawings reviewed and stamped by a registered professional engineer having registration in the State of New Mexico or other procedure acceptable to the AHJ. Submit a copy of the current certification of the NICET technician and the registered Engineer with the initial submittal.

1.07 EXTRA MATERIALS

A. Furnish, tag, and box for shipment and storage the following spare parts, special tools, and materials:

Item	Quantity
Sprinkler Cabinet	One each
Sprinklers	Six of each different size unit

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Item	Quantity
Special tools required to maintain or dismantle	One complete set for each different size unit

B. Delivery: In accordance with Section 01 61 00, Common Product Requirements.

PART 2 PRODUCTS

2.01 GENERAL

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Sprinkler system equipment, specialties, accessories, installation, and testing: comply with NFPA 13.

C. Piping Materials: Comply with requirements in “Piping Schedule” located below.

2.02 STEEL PIPE AND FITTINGS

A. Pipe:

1. FM Approved Standard Weight, Galvanized and Black Steel Pipe: ASTM A53/A53M or ASTM A153. Pipe ends may be factory or field formed to match joining method.
2. FM Approved Schedule 30, Galvanized and Black Steel Pipe: ASTM A135/A135M or ASTM A795/A795M. Pipe ends may be factory or field formed to match joining method.
3. FM Approved Thinwall Galvanized and Black Steel Pipe: ASTM A135/A135M or ASTM A795/A795M, threadable, with wall thickness less than Schedule 30 and equal to or greater than Schedule 10. Pipe ends may be factory or field formed to match joining method.
4. Do not use lightwall pipe and Schedule 5 pipe.

B. Fittings:

1. Galvanized and Uncoated, Gray-Iron Threaded Fittings: ASME B16.4, Class 125, standard pattern. Provide galvanized fittings and couplings:
   a. Where scheduled.
   b. Exterior locations.

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2. Flanges:
    a. Cast Iron: ASME B16.1 or AWWA C110, AWWA C111, AWWA C115, 250 psi water service rating, Class 125 dimensions and bolt pattern.
    b. Galvanized and Uncoated, Steel Flanges and Flanged Fittings: ASME B16.5, Class 150.
3. Grooved-Joint, Steel Pipe Appurtenances:
    a. Galvanized and Uncoated, Grooved-End Fittings and Couplings for Steel Piping: UL 213 listed for fire protection service, FM approved, malleable-iron casting or ductile-iron casting; with dimensions matching steel pipe. Standard EPDM gaskets. Rigid type except where flexible type is required for vibration isolation or stress relief.
    b. Manufacturers:
        1) Tyco.
        2) Victaulic Company.
4. Certify fittings, couplings, flanges, and flange adaptors used with thinwall pipe or Schedule 10 pipe by the fitting manufacturer as dimensionally compatible with and fully connectable to the pipe used without field modifications.
5. Welded or segmented fittings are not acceptable.

2.03 PIPING SCHEDULE

A. Piping Between Fire Department Connections and Check Valves: Galvanized, standard-weight steel pipe with threaded ends; cast-iron threaded fittings; and threaded joints.

B. Standard-pressure, Wet-pipe Sprinkler System, 2 inches and Smaller:

1. Standard-weight or Schedule 30, black steel pipe with threaded ends; uncoated, gray-iron threaded fittings; and threaded joints.
2. Standard-weight or Schedule 30, galvanized steel pipe with threaded ends; galvanized, gray-iron threaded fittings; and threaded joints.
3. Standard-weight or Schedule 30, black steel pipe with cut- or roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end pipe couplings for steel piping; and grooved joints.
4. Standard-weight or Schedule 30, black steel pipe with plain ends; steel welding fittings; and welded joints.

C. Standard-pressure, Wet-pipe Sprinkler System, 2-1/2 inches to 4 inches:

1. Standard-weight or Schedule 30, black steel pipe with cut- or roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end pipe couplings for steel piping; and grooved joints.

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2. Standard-weight or Schedule 30, galvanized steel pipe with cut-grooved ends; galvanized, grooved-end fittings for steel piping; grooved-end pipe couplings for steel piping; and grooved joints.
3. Standard-weight or Schedule 30, black steel pipe with plain ends; steel welding fittings; and welded joints.
4. Schedule 10, black steel pipe with roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end pipe couplings for steel piping; and grooved joints.
5. Schedule 10, black steel pipe with plain ends; welding fittings; and welded joints.

D. Standard-pressure, Wet-pipe Sprinkler System, 5 inches and Larger:

1. Standard-weight or Schedule 30, black steel pipe with cut- or roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end pipe couplings for steel piping; and grooved joints.
2. Standard-weight or Schedule 30, galvanized steel pipe with cut-grooved ends; galvanized, grooved-end fittings for steel piping; grooved-end pipe couplings for steel piping; and grooved joints.
3. Standard-weight or Schedule 30, black steel pipe with plain ends; steel welding fittings; and welded joints.
4. Schedule 10, black steel pipe with roll-grooved ends; uncoated, grooved-end fittings for steel piping; grooved-end pipe couplings for steel piping; and grooved joints.
5. Schedule 10, black steel pipe with plain ends; welding fittings; and welded joints.
6. Standard-weight or Schedule 30, galvanized steel pipe with cut-grooved ends; galvanized, grooved-end fittings for steel piping; grooved-end pipe couplings for steel piping; and grooved joints.
7. Standard-weight or Schedule 30, black steel pipe with plain ends; steel welding fittings; and welded joints.
8. Schedule 10, black steel pipe with plain ends; welding fittings; and welded joints.

2.04 PIPING JOINING MATERIALS

A. Pipe Flange Gasket Materials: AWWA C110/A21.10, rubber, flat face, 1/8 inch (3.2 mm) thick.

1. Class 125, Cast-Iron Flanges and Class 150, Bronze Flat-Face Flanges: Full-face gaskets.
2. Class 250, Cast-Iron Flanges and Class 300, Steel Raised-Face Flanges: Ring-type gaskets.

B. Metal Pipe Flange Bolts and Nuts: ASTM A307 Grade B, galvanized, with galvanized nuts in accordance with ASTM A563 Grade A.

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C. Unions: 150 psig galvanized malleable iron, ASTM A197, threaded, ground joint, integral seat.

2.05 VALVES

A. General Requirements:

1. Valves shall be UL listed or FM approved.
2. Minimum Pressure Rating for Standard-Pressure Piping: 175 psig.
3. Make flanged end and wafer type valves compatible for installation with flanges as specified.

B. Ball Valves:

1. Standard: UL 1091, except with ball instead of disc.
2. 1-1/2 Inches and Smaller: Bronze body with threaded ends.
3. 2 Inches and 2-1/2 Inches: Bronze body with threaded ends or ductile-iron body with grooved ends.
4. 3 Inches: Ductile-iron body with grooved ends.
5. Manufacturers:
   a. Anvil International, Inc.
   b. Victaulic Company.

C. Iron Butterfly Valves:

1. Standard: UL 1091.
2. Pressure Rating: 175 psig.
3. Body Material: Cast or ductile iron.
4. Stem: Stainless steel.
5. Style: Lug or wafer.
6. End Connections: Grooved.
7. Manufacturers:
   a. Global Safety Products, Inc.
   b. NIBCO INC.
   c. Tyco.
   d. Victaulic Company.

D. Check Valves:

1. Standard: UL 312.
2. Pressure Rating: 250 psig minimum.
3. Type: Swing check or spring assisted swing check.
4. Body Material: Cast or ductile iron.
5. End Connections: Flanged or grooved.
6. Manufacturers:
   a. Kennedy Valve.
   b. Mueller Company.

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c. NIBCO INC.
d. Tyco.
e. Victaulic Company.

E. Iron OS&Y Gate Valves:

1. Standard: UL 262.
2. Pressure Rating: 250 psig minimum.
3. Body Material: Cast or ductile iron.
4. End Connections: Flanged or grooved.
5. Manufacturers:
   a. Kennedy.
   b. Mueller Co.; Water Products Division.
   c. NIBCO INC.
   d. Tyco.
   e. Victaulic Company.

F. Indicating-Type Butterfly Valves:

1. Standard: UL 1091.
2. Pressure Rating: 175 psig minimum.
3. Valves 2 Inches and Smaller:
   a. Valve Type: Ball or butterfly.
   b. Body Material: Bronze.
   c. End Connections: Threaded or grooved.
4. Valves 2-1/2 Inches and Larger:
   a. Valve Type: Butterfly.
   b. Body Material: Cast or ductile iron.
   c. Stem Material: Stainless steel.
   d. End Connections: Flanged, grooved, or wafer.
5. Valve Operation: Weatherproof actuator housing with handwheel and integral dual single-pole, double-throw (SPDT) (Form C) contacts, rated for a minimum of 10 amps at 125/250V ac, 2 amps at 30V dc, 10 mA minimum at 24V dc in tamper-proof cover with mounting and required hardware for attachment to indicated valves indicating device.
6. Manufacturers:
   a. Kennedy Valve.
   b. NIBCO INC.
   c. Tyco.
   d. Victaulic Company.

G. NRS Gate Valves:

1. Standard: UL 262.
2. Pressure Rating: 250 psig minimum.
3. Body Material: Cast iron with indicator post flange.

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4. Stem: Nonrising.
5. End Connections: Flanged or grooved.
6. Manufacturers:
    a. Kennedy Valve.
    b. Mueller Co.
    c. NIBCO INC.
    d. Tyco.
    e. Victaulic Company.

H. Indicator Wall Posts:

1. Standard: UL 789.
2. Type: Horizontal for wall mounting.
3. Body Material: Cast iron with extension rod and locking device.
4. Operation: Wrench.
5. Manufacturers:
    a. Kennedy Valve.
    b. Mueller Co.
    c. NIBCO INC.
    d. Tyco.
    e. Victaulic Company.

2.06 TRIM AND DRAIN VALVES

A. General:

1. Standard: UL's "Fire Protection Equipment Directory" listing or FM "Approval Guide," listing.
2. Pressure Rating: 175 psig minimum.

B. Angle Valves:

1. Manufacturers:
    a. Fire Protection Products, Inc.
    b. Potter-Roemer.
    c. United Brass Works, Inc.

C. Ball Valves:

1. Manufacturers:
    a. NIBCO INC.
    b. Potter Roemer.
    c. Tyco.
    d. Victaulic Company.

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2.07 SPECIALTY VALVES

A. General Requirements:

1. Standard: UL's "Fire Protection Equipment Directory" listing or FM "Approval Guide" listing.
2. Pressure Rating:
   a. Standard-Pressure Piping Specialty Valves: 175 psig minimum.
   b. High-Pressure Piping Specialty Valves: 250 psig minimum.
3. Body Material: Cast or ductile iron.
4. Size: Same as connected piping.
5. End Connections: Flanged or grooved.

B. Alarm Valves:

1. Standard: UL 193.
2. Design: Vertical installation.
3. Valve internal components shall be replaceable without removing the valve from the installed position.
4. Include trim sets for bypass, drain, electrical sprinkler alarm switch, pressure gauges, retarding chamber, and fill-line attachment with strainer.
5. Drip Cup Assembly: Pipe drain with check valve to main drain piping.
6. Manufacturers:
   a. Tyco; Series AV.
   b. Victaulic Company; Series 751.
   c. Viking Corporation; Series J-1.

2.08 FIRE DEPARTMENT CONNECTIONS

A. Exposed-Type:

1. Standard: UL 405.
2. Type: Exposed, projecting, for wall mounting.
3. Pressure Rating: 175 psig minimum.
4. Body Material: Corrosion-resistant metal.
5. Inlets: Brass with threaded connections according to NFPA 1963 and matching local fire department requirements; include extension pipe nipples, brass lugged swivel connections, and check devices or clappers. Verify inlet connections with local fire authority.
6. Caps: Brass, lugged type, with gasket and chain.
7. Escutcheon Plate: Round, brass, wall type.
8. Outlet: Back, with pipe threads.
9. Number of Inlets: Two.
10. Escutcheon Plate Marking: Similar to "AUTO SPKR."
11. Finish: Polished chrome plated.
12. Outlet Size: 2-1/2 inches.

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13. Manufacturers:
    a. Elkhart Brass Mfg. Company, Inc.
    b. Guardian Fire Equipment, Inc.
    c. Potter-Roemer.
    d. Tyco.

B. Fire Department Outlet Test Fitting:

1. Brass body and polished chrome plated plate lettered HYDRANT.
2. Polished brass female 4-inch NPT by 2-1/2-inch male hose thread snoots with caps and chains.
3. Two-way hydrant with two outlets and inlet configuration as required for location.
4. Manufacturers:
    a. Elkhart Brass Mfg. Company, Inc.
    b. Guardian Fire Equipment, Inc.
    c. Potter Roemer.
    d. Tyco.

2.09 SPRINKLER SPECIALTY PIPE FITTINGS

A. Branch Outlet Fittings:

1. Standard: UL 213.
2. Pressure Rating: 175 psig minimum.
3. Body Material: Ductile-iron housing with EPDM seals and bolts and nuts.
4. Type: Mechanical-cross fittings.
5. Configurations: Snap-on and strapless, ductile-iron housing with branch outlets.
6. Size: Dimension to fit on sprinkler main and with outlet connections as required to match connected branch piping.
7. Branch Outlets: Grooved, plain-end pipe, or threaded.
8. Manufacturers:
    a. Tyco.
    b. Victaulic Company.

B. Flow Detection and Test Assemblies:

1. Standard: UL's "Fire Protection Equipment Directory" listing or FM "Approval Guide" listing.
2. Pressure Rating: 175 psig minimum.
3. Body Material: Cast-iron or ductile-iron housing with orifice, sight glass, and integral test valve.
4. Size: Same as connected piping.
5. Inlet and Outlet: Threaded or grooved.

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6. Manufacturers:
    a. Reliable Automatic Sprinkler Co., Inc.
    b. Tyco.
    c. Victaulic Company.

C. Branch Line Testers:

1. Standard: UL 199.
2. Pressure Rating: 175 psig.
3. Body Material: Brass.
4. Size: Same as connected piping.
5. Inlet: Threaded.
6. Drain Outlet: Threaded and capped.
7. Branch Outlet: Threaded, for sprinkler.
8. Manufacturers:
    a. Elkhart Brass Mfg. Company, Inc.
    b. Potter-Roemer.

D. Sprinkler Inspector's Test Fittings:

1. Standard: UL's "Fire Protection Equipment Directory" listing or FM "Approval Guide" listing.
2. Pressure Rating: 175 psig minimum.
3. Body Material: Cast-bronze, cast-iron, or ductile-iron housing with sight glass.
4. Size: Same as connected piping.
5. Inlet and Outlet: Threaded or grooved.
6. Manufacturers:
    a. Tyco.
    b. Victaulic Company.
    c. Viking Corporation.

E. Flexible, Sprinkler Hose Fittings:

1. Standard: UL 1474.
2. Type: Flexible braided Type 304 stainless steel flexible tube hose for connection to sprinkler, and with bracket for connection to ceiling grid.
3. Pressure Rating: 175 psig minimum.
4. Size: Same as connected piping, for sprinkler.
5. Manufacturers:
    a. Fivalco Inc.
    b. FlexHead Industries, Inc.
    c. Gateway Tubing, Inc.
    d. Victaulic Company.

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2.10 SPRINKLERS

A. General:

1. Standard: UL's "Fire Protection Equipment Directory" listing or FM "Approval Guide" listing.
2. Pressure Rating
    a. Residential Sprinklers: 175 psig maximum.
    b. Automatic Sprinklers: 175 psig minimum.

B. Sprinkler Schedule

1. Use sprinkler types below for the following applications:
    a. Rooms without Ceilings: Upright sprinklers.
    b. Rooms with Suspended Ceilings: Pendent sprinklers.
    c. Wall Mounting: Sidewall sprinklers.
    d. Spaces Subject to Freezing: Pendent, dry sprinklers and sidewall, dry sprinklers.
2. Provide sprinkler types below with finishes indicated.
    a. Upright, Pendent and Sidewall Sprinklers: Chrome plated in finished spaces exposed to view; rough bronze in unfinished spaces not exposed to view; wax coated where exposed to acids, chemicals, or other corrosive fumes.

C. Automatic Sprinklers with Heat-Responsive Element:

1. Early-Suppression, Fast-Response Applications: UL 1767.
2. Nonresidential Applications: UL 199.
3. See Drawings for additional information.
4. Sprinkler Finishes:
    a. Chrome plated.
    b. Bronze.
    c. Painted.
5. Special Coatings:
    a. Wax.
    b. Lead.
    c. Corrosion-resistant paint.
6. Sprinkler Escutcheons:
    a. Escutcheons for concealed, flush, and recessed-type sprinklers are specified with sprinklers.
    b. Ceiling Mounting: Chrome-plated steel, one piece, flat.
    c. Sidewall Mounting: Chrome-plated steel, one piece, flat.
7. Sprinkler Guards:
    a. Standard: UL 199.
    b. Type: Wire cage with fastening device for attaching to sprinkler.

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8. Manufacturers:
    a. Reliable Automatic Sprinkler Co., Inc.
    b. Tyco.
    c. Victaulic Company.
    d. Viking Corporation.

2.11 ALARM DEVICES

A. Alarm-device types shall match piping and equipment connections.

B. Electrically Operated Alarm Bell:

1. Standard: UL 464.
2. Type: Vibrating, metal alarm bell.
3. Size: Minimum 6-inch (150-mm) diameter.
4. Finish: Red enamel factory finish, suitable for outdoor use.
5. UL listed and FM approved.
6. Manufacturers:
    a. Fire-Lite Alarms, Inc.; a Honeywell company.
    b. Notifier; a Honeywell company.
    c. Potter Electric Signal Company.

C. Water Flow Indicators:

1. Standard: UL 346.
2. Water Flow Detector: Electrically supervised.
3. Components: Provide device with two sets of SPDT (Form C) contacts. Provide minimum switch electrical rating of 10 amps at 125/250V ac, 2 amps at 30V dc resistive, 10 mA at 24V dc.
4. Type: Paddle operated.
5. Pressure Rating: 250 psig.
6. Installation: Horizontal or vertical.
7. UL listed and FM approved.
8. Manufacturers:
    a. Potter Electric Signal Company.
    b. System Sensor; a Honeywell company.
    c. Tyco.
    d. Viking Corporation.

D. Pressure Switches:

1. Standard: UL 346.
2. Type: Electrically supervised water flow switch with retard feature.
3. Components: Provide device with two sets of SPDT (Form C) contacts. Provide minimum switch electrical rating of 10 amps at 125/250V ac, 2 amps at 30V dc resistive, 10 mA at 24V dc.
4. Operation: Rising pressure signals water flow.

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5. UL listed and FM approved.
6. Manufacturers:
    a. Potter Electric Signal Company.
    b. System Sensor; a Honeywell company.
    c. Tyco.
    d. Viking Corporation.

E. Valve Supervisory Switches:

1. Standard: UL 346.
2. Type: Electrically supervised.
3. Components: Single unit composed of dual single-pole, double-throw (SPDT) (Form C) contacts, rated for a minimum of 10 amps at 125/250V ac, 2 amps at 30V dc, 10 mA minimum at 24V dc in tamper-proof cover with mounting hardware for attachment to indicated valves.
4. Design: Signals that controlled valve is in other than fully OPEN position.
5. UL listed and FM Approved.
6. Manufacturers:
    a. ADT Security Services, Inc.
    b. Potter Electric Signal Company.
    c. System Sensor; a Honeywell company.

2.12 MANUAL CONTROL STATIONS

A. Description:

1. UL listed or FM approved.
2. Hydraulic operation, with union, 1/2-inch pipe nipple, and bronze ball valve.
3. Metal enclosure labeled “MANUAL CONTROL STATION”.
4. Cover held closed by breakable strut to prevent accidental opening.

2.13 PRESSURE GAUGES

A. Description:

1. Standard: UL 393.
2. Dial Size: 3-1/2-inch to 4-1/2-inch (90-mm to 115-mm) diameter.
3. Pressure Gauge Range: 0 psig to 250 psig minimum.
4. Water System Piping Gauge: Include “WATER” or “AIR/WATER” label on dial face.
5. Air System Piping Gauge: Include “AIR” or “AIR/WATER” label on dial face.
6. Manufacturers:
    a. AMETEK; U.S. Gauge Division.
    b. Ashcroft, Inc.

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c. Brecco Corporation.
d. WIKA Instrument Corporation.

2.14 SLEEVES AND PENETRATIONS FOR PIPING SYSTEMS

A. Sleeves:

1. Walls:
   a. Interior and Exterior Walls: Schedule 40 carbon steel.
   b. Concrete: Cast-iron wall sleeves with integrally cast water stop.
   c. Interior Partitions: 22-gauge (U.S. Standard) minimum galvanized sheet steel.
2. Interior Floor: Schedule 40 carbon steel.
3. Slab on Grade: Cast-iron wall sleeves with integrally cast water stop.
4. Underground (Beneath Foundations, Footings, Grade Beams): Standard weight corrugated steel, bituminous coating inside and outside, with close-fitting bituminous coated plate at each end.

B. Sleeve and Penetration Packing:

1. Modular Wall and Casting Seals: Link-Seal as manufactured by Thunderline Corporation, Flexicraft Pipe Seal. Sleeve and modular wall and casting seal to be furnished together as a single integrated unit.
2. Penetration Packing (With or Without Sleeve) for Interior Walls and Interior Elevated Floors:
   a. UL listed, FM approved materials and sealant systems, by 3M Fire Barrier Wrap/Strip FS-195+.
   b. Flexible elastomeric material unless specified otherwise.
   c. Include additional materials and accessories to meet requirements of manufacturer and this section.
   d. Compatible with penetrated surface.
   e. Hazard Ratings:
      1) Pipes Penetrating Fire Rated Walls, Fire Rated Ceilings, and Fire Rated Floor Slabs (1 hour or greater): Material having maximum flame spread of 25 and maximum smoke develop rating of 50, selected to maintain fire rating of penetrated surface.
      2) Pipes Penetrating Other Interior Walls: Material having maximum smoke develop rating of 50, selected to prevent smoke transmission through penetration.
      3) Pipes Penetrating Nonrated Interior Floors: Mineral wool and fire-rated caulk.

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PART 3 EXECUTION

3.01 PREPARATION

A. Perform fire hydrant flow test according to NFPA 13 and NFPA 291.

B. Submit test results promptly.

3.02 SERVICE-ENTRANCE PIPING

A. Connect sprinkler piping to fire main piping for service entrance to building.

B. Install shutoff valve, backflow preventer, pressure gauge, drain, and other accessories indicated at connection to fire main piping.

3.03 PIPING INSTALLATION

A. Locations and Arrangements:

1. Install piping in accordance with approved Shop Drawings, schematics, and diagrams which indicate general location and arrangement of piping.
2. Deviations from approved piping Shop Drawings require written approval from AHJ. Submit written approval to Engineer before deviating from approved working plans.

B. Piping Standard: Comply with NFPA 13 sprinkler piping installation requirements.

C. Seismic Design Category (SDC) is shown on Structural General Notes on Drawing 000-G-0301

D. Based on the SDC, seismic bracing is required for this Project.

E. Use listed fittings to make changes in direction, branch takeoffs from mains, and reductions in pipe sizes.

F. Install unions adjacent to each valve in pipe 2 inches and smaller.

G. Install “Inspector’s Test Connections” in sprinkler system piping, complete with shutoff valve, sized and located according to NFPA 13.

H. Install sprinkler piping with drains for complete system drainage.

I. Install sprinkler control valves, test assemblies, and drain risers adjacent to standpipes when sprinkler piping is connected to standpipes.

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J. Install automatic drain valve at each check valve for fire department connection, to drain piping between fire department connection and check valve. Install drain piping to and spill over floor drain or to outside building.

K. Install alarm devices in piping systems.

L. Install hangers and supports for sprinkler system piping according to NFPA 13. Comply with NFPA 13 requirements for hanger materials.

M. Install pressure gauges on riser or feed main, at each sprinkler test connection, and at top of each standpipe.

1. Include pressure gauges with connection not less than 1/4 inch and with soft metal seated globe valve, arranged to drain pipe between gauge and valve.
2. Install gauges to permit removal, and where not subject to freezing.

N. Fill sprinkler system piping with water.

O. Install sleeves for piping penetrations of walls, ceilings, and floors.

P. Install sleeve seals for piping penetrations of concrete walls and slabs.

Q. Install escutcheons for piping penetrations of walls, ceilings, and floors.

3.04 JOINT CONSTRUCTION

A. Steel Piping:

1. Pressure-Sealed Joints: Join lightwall steel pipe and steel pressure-seal fittings with tools recommended by fitting manufacturer.
2. Welded Joints: Construct joints according to NFPA 13, using qualified processes and welding operators according to Article Quality Assurance.
   a. Shop-weld pipe joints where welded piping is indicated.
   b. Do not use welded joints for galvanized-steel pipe.
3. Cut-Grooved and Roll-Grooved Joints:
   a. Cut square-edge groove or roll rounded-edge groove in end of pipe according to NFPA 13.
   b. Install grooved joints in accordance with the manufacturer’s latest published installation instructions.
   c. Provide grooved ends clean and free from indentations, projections, and tool marks.
   d. Join steel pipe and grooved-end fittings according to NFPA 13 for steel pipe joints.

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B. Dissimilar-Material Piping Joints: Make joints using adapters compatible with materials of both piping systems.

3.05 VALVE AND SPECIALTIES INSTALLATION

A. Install listed fire protection valves, trim and drain valves, specialty valves and trim, controls, and specialties according to NFPA 13 and AHJ.

B. Install listed fire protection shutoff valves supervised open, located to control sources of water supply other than fire department connections. Install permanent identification signs indicating portion of system controlled by each valve.

C. Install check valve in each water supply connection. Install backflow preventers instead of check valves in potable water supply sources.

D. Specialty Valves:

1. General Requirements: Install in vertical position for proper direction of flow, in main supply to system.
2. Alarm Valves: Include bypass check valve and retarding chamber drain line connection.

E. Specialty Sprinkler Fittings: Install downstream of control valves instead of specified fittings if indicated in approved Shop Drawings.

3.06 SPRINKLER INSTALLATION

A. Install sprinklers in suspended ceilings in center of acoustical ceiling panels.

B. Install dry-type sprinklers with water supply from heated space. Do not install pendent or sidewall, wet-type sprinklers in areas subject to freezing.

C. Install sprinklers into flexible, sprinkler hose fittings and install hose into bracket on ceiling grid.

D. Do not install any sprinklers that have been dropped, damaged, or show a visible loss of fluid. Never install any sprinkler with a cracked bulb.

E. Remove sprinkler bulb protector by hand. Do not use any tools or devices that could damage the bulb.

3.07 FIRE DEPARTMENT CONNECTION INSTALLATION

A. Install wall-type, fire department connection.

B. Install automatic drain valve at each check valve for fire department connection.

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3.08 IDENTIFICATION

A. Install labeling and pipe markers on equipment and piping according to NFPA 13 requirements.

B. Identify system components.

3.09 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Leak Test: After installation, charge systems and test for leaks. Repair leaks and retest until leak free.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Flush, test, and inspect sprinkler systems according to NFPA 13.
4. Energize circuits to electrical equipment and devices.
5. Coordinate with fire alarm tests. Operate as required.
6. Coordinate with fire pump tests. Operate as required.
7. Demonstrate that equipment hose threads match local fire department equipment.

B. Sprinkler piping system is defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

1. Field Test Reports and Certificates: Indicate and interpret test results for compliance with performance requirements and as described in NFPA 13; include “Contractor’s Material and Test Certificate for Aboveground Piping.”

3.10 MANUFACTURER’S SERVICES

A. Manufacturer’s Representative: Present at Site or classroom designated by Owner, for minimum person-days listed below, travel time excluded:

1. 3 person-days for installation assistance and inspection.
2. 3 person-days for functional and performance testing and completion of Manufacturer’s Certificate of Proper Installation.
3. 2 person-days for prestartup classroom or Site training.
4. 1 person-day for facility startup.
5. 1 person-day for post-startup training of Owner’s personnel. Do not commence training until a detailed lesson plan for each training activity has been accepted by Owner.

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3.11 CLEANING

A. Clean dirt and debris from sprinklers.

B. Remove and replace sprinklers with paint other than factory finish.

END OF SECTION

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SECTION 21 30 01
DIESEL FIRE PUMP SYSTEM AND ACCESSORIES

PART 1 GENERAL

1.01 SUMMARY

A. Section includes: Provision, delivery, receiving, unloading, installation, and startup of the following:

1. One diesel engine-driven fire pump, with drive, fuel system, jockey pump, associated controllers, interconnecting piping, and interconnecting wiring.

1.02 QUALITY ASSURANCE

A. Comply with current adopted edition of International Building Code (IBC), International Fire Code (IFC), NFPA 20, NEC (NFPA 70), and state and local codes of New Mexico.

B. Design to satisfy seismic design requirements in accordance with current adopted edition of IBC and the following criteria as indicated on Drawing 000-G-0301.

C. Test pumps, drives, and controllers at factory to ensure performance as specified and as required by NFPA 20. Provide copies of certified factory test data for comparison during field acceptance tests.

D. Test packaged pumping system at factory with water to 200 psig or at 50 psi over the maximum pressure to be maintained in the system, whichever is greater.

E. Test electrical components for proper configuration, connection, and operability.

F. Furnish materials that are new, unused, and free from cracks or imperfections.

G. Provide services of qualified manufacturer's representative to assist in installation and complete checkout and startup of equipment. (See also Article entitled "INSTALLATION" of this Section.)

H. Provide repair, maintenance, and parts supply service for furnished components.

I. Do not commence fabrication and assembly of packaged system and enclosure until review of submittal data by Owner's Representative is completed.

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J. Engineer and Owner's Representative inspection of construction of packaged pump house module at the manufacturer with 24 hours' notice.

K. Select operating items inside enclosure, including mechanical components, electrical components, controls, and instrumentation, for operation in an indoor environment of between 40 degrees F and 104 degrees F.

L. Include sufficient quantities of proper lubricants as required and specified by equipment manufacturer for complete lubrication during field tests and initial operation.

M. Provide and design system in accordance with requirements of Owner's insurance underwriter and the authority having jurisdiction (AHJ) for the Project location.

1.03 SUBMITTALS

A. Refer to the Submittal Schedule at the end of Part 3 of this Section for a list of submittal requirements for this Section.

1.04 QUALIFICATIONS

A. Responsible for compliance with applicable codes.

B. Minimum 5 years' experience in production and assembly of fire pumps with related components as specified and in compliance with NFPA 20.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Protect equipment, enclosure components, connection surfaces, piping, wiring, fluid passages, and working parts from damage during shipment, handling, and storage.

B. Delivered Configuration:

1. Factory assemble each packaged pumping system and enclosure and ship as a complete unit unless:
   a. Shipment in sections is absolutely required.
   b. Certain components (such as fuel vent line, heater, test header, engine muffler, and engine exhaust piping) must be field installed.
   c. Shipping restrictions or equipment limitations dictate that smaller portions must be shipped.
2. Provide supervision of field assembly and installation to provide complete operational fire pump packages within a complete functioning enclosure or building as specified and to Owner's satisfaction.

C. Deliver equipment and accessories to specified location for unloading.

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D. Repair or replace items damaged during shipment and delivery.

E. Store equipment in a dry indoor location, in a manner which facilitates inspection and measurement of quantity. Protect stored products from loss by falling objects and exposure to rain, wind-driven dust, sand, grit, and other similar phenomena.

F. Retain protective covering materials and coatings during storage.

G. Receive, unload, and transport equipment on Project site.

1.06 WARRANTY

A. Warrant that supplied components will function as specified and as a complete functional system in accordance with applicable codes and be free from defects in design, assembly, manufacture, and workmanship for a minimum period of 1 year after equipment is placed in service.

PART 2 PRODUCTS

2.01 SYSTEM COMPONENTS

A. Fire Pumps:

1. Quantity: One.
2. Design: Delivery of not less than 65 percent of rated head at 150 percent of rated capacity.
3. Maximum Shutoff Head: 120 percent of rated head, maximum.
4. Operating Conditions:
   a. Rated Capacity: 1500 gpm.
   b. Total Rated Head (Total Dynamic Head or TDH): 200 feet.
5. Vertical Turbine Pump, Diesel Engine Driven:
   a. The fire pump shall be a vertical shaft turbine pump. The pump shall be specifically labeled for fire service system. The water supply for the fire pump shall be from the finish water well.
   b. The pump discharge head assembly shall be cast iron and fitted with a discharge connection machined to ANSI 125-pound rating dimensions.
   c. The pump discharge head shall provide rigid mounting support for the complete pump assembly and for the right angle gear drive.
   d. The pump line shaft bearings shall be water lubricated by the liquid being pumped.
   e. Pump column pipe shall be in sections not longer than 10 feet each. Pump bowl assemblies shall include cast iron enameled bowls, cast bronze impellers and bowl lateral seal rings. Pump bowl assemblies shall be submerged as recommended in NFPA Pamphlet 20. Each pump shall be installed with a cast or

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fabricated nonferrous metal strainer having a free area of not less than four times the suction inlet area. Strainer openings shall be sized to restrict the passage of objects 1/2-inch sphere size.

6. Fittings: The pump manufacturer shall furnish piping accessory items for the pump installation which will adapt the pump connections to the fire protection system and test connection as follows. Fittings subjected to pump discharge pressure shall be ANSI 125-pound rating. Fittings subjected to suction pressure shall be ANSI 125-pound rating.
7. Gear Drives: Engine driven vertical turbine pumps shall be furnished with a vertical hollow shaft right-angle gear. The drive shall be direct connected to the pump shaft and be equipped with a non-reverse ratchet. The drive shall be connected to the engine by an approved flexible universal joint type drive shaft with an enclosing guard as recommended in NFPA Pamphlet 20. The driver shall have provision for adjusting the pump impeller lateral setting for proper pump operation and performance.
8. Pump Design and Construction: Pump UL listed and FM approved.

B. Jockey (Pressure Maintenance) Pump:

1. Quantity: One.
2. Configuration: Vertical.
3. Type: Centrifugal or multistage diffuser, FM approved, direct drive by electric motor.
4. Materials:
   a. Casing: Cast iron.
   b. Shaft: Steel.
   c. Trim and Impeller: Bronze.
5. Operating Conditions:
   a. Capacity: 20 gpm.
   b. Total Head (TDH): 220 feet.
   c. Speed: 3500 rpm maximum.
6. Provide accessories including, but not necessarily limited to:
   a. Common rigid structural steel baseplate for pump and drive, elevated as required,
   b. Manufacturer’s nameplate stating:
      1) Pump capacity,
      2) Total head, and
      3) Manufacturer’s model number and serial number.
   c. Motor: TEFC, 1.15 service factor, NEMA design “B”, 460/3/60.

C. Diesel Engine Drive:

1. Quantity: One diesel engine-driven fire pump.
2. Type: Direct drive, UL listed, FM approved, designed for operation on diesel fuel for fire pump service, in accordance with NFPA 20.

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3. Horsepower Rating: Not less than 110 percent of maximum brake horsepower (after derating for altitude in accordance with NFPA 20) required to drive pump at rated speed.
4. Altitude Correction:
    a. Correct power rating prior to making any other power corrections.
    b. Altitude Above Sea Level: Approximately 5,400 feet.
5. Provide accessories for each drive including but not limited to following:
    a. Adjustable governor capable of regulating speed within range of 10 percent between shutoff and maximum load conditions of pumps.
    b. Overspeed Shutdown Device:
        1) Designed to stop engine at 10 percent above rated speed.
        2) Position: Supervised so automatic controller will show overspeed trouble signal until shutdown device is manually reset.
        3) Provide manual reset.
    c. Speed Switch:
        1) Function: Signal engine running and crank termination.
        2) Source of Power: Source other than engine generator or alternator.
    d. Instrument panel including but not limited to:
        1) Tachometer.
        2) Oil pressure gauge.
        3) Water temperature gauge.
        4) Hour meter.
    e. Cooling System:
        1) Type: Closed circuit.
        2) Water Source: Discharge side of fire pump.
        3) Components:
            a) Engine driven circulating pump.
            b) Heat exchanger.
            c) Engine jacket temperature regulator or thermostat.
            d) Two manual shutoff valves for cooling water supply.
            e) Strainer for cooling water supply.
            f) Pressure regulating valve for cooling water supply.
            g) Automatic electric solenoid valve for cooling water supply.
            h) Pressure gauge for engine side of cooling water supply before last manual valve.
            i) Valved bypass around circuit from inlet side of first manual valve to outlet side of second manual valve.
            j) Visible open waste cone, as required.
    f. Water-cooled jacketed exhaust manifold.
    g. Jacket water heater, 120V ac, single phase, 60 Hertz.
    h. Flexible metallic fuel lines, with necessary protection.

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i. In-line fuel filter.
j. Oil pressure safety switch.
k. Air cleaner.
l. Engine driven oil pump.
m. Enclosed control wiring.
n. Electric starter with voltage regulator.
o. Two heavy duty lead acid or nickel-cadmium batteries, negative ground, with corrosion resistant battery rack and cables as required; charged from engine generator or alternator and automatic trickle charger.
p. Residential grade engine exhaust silencer with spark arrestor, flexible exhaust connection, ventilated thimble (as required) and suitable factory-painted supports for supporting silencer.
q. Horizontal factory-painted double wall carbon steel UL labeled fuel storage tank, 240 gallons storage capacity, with legs, level gauge, low level switch, vent with flame arrestor, and necessary connections for fill, outlet, and fuel return.

D. Engine Driven Fire Pump Controller:

1. Quantity: One for diesel engine drive.
2. Enclosure: NEMA 12 certified, drip proof, floor mounted, moisture and dust resistant, heavy steel, premounted; include heavy gauge steel door with continuous hinge and three-point lockable latch.
3. Type: UL listed FM approved combined manual/automatic, arranged for automatic start on reduction in water line pressure and manual stop only, completely factory wired and tested.
4. Include following:
   a. Pressure switch, adjustable.
   b. Dual automatic battery charger with necessary ammeters and volt meters, rectified to continuously keep both batteries fully charged.
   c. Four position manual selection station (manual-automatic-off-test).
   d. Pilot light to indicate pump running.
   e. Pilot light for indicating controller not in automatic position.
   f. Pilot light for each battery supply.
   g. Alarm relay for AC power failure with time delay to prevent alarm activation for power failures of 10 seconds or less.
   h. Individual pilot lights with common audible alarm, for indicating trouble caused by:
      1) Low lubrication oil pressure.
      2) High water temperature in engine jacket.
      3) Failure to start.
      4) Overspeed shutdown.

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5) Battery failure (separate lamps each battery).
6) AC power failure.
7) Low fuel level.

i. Tamper-proof solid state crank cycle timer.
j. Pushbutton for manually stopping pump after starting causes have returned to normal.
k. Reset pushbutton or switch for battery failure alarm.
l. Audible alarm (bell or siren) for local trouble or failure.
m. Manual start pushbutton for cranking engine.
n. Solenoid drain valve.

5. Provide minimum three sets of form "C" dry contacts for remote annunciation of the following conditions:
   a. Controller in engine running condition.
   b. Controller in "manual" or "off" position.
   c. Trouble – common alarm for:
      1) Low lubrication oil pressure.
      2) High engine jacket water temperature.
      3) Failure to start.
      4) Overspeed shutdown.
      5) Battery failure.
      6) Loss of battery charger output on load side of dc overcurrent protection device.
      7) AC power failure.
      8) Low fuel level.
6. Provide weekly program timer.
7. Include provision for weekly automatic 30-minute test run.
8. Include 7-day chart recorder for recording water line pressure.
9. Include wiring diagram, operating sequence description, instructions, and parts list inside door.

E. Jockey Pump Controller:

1. Quantity: One each jockey pump.
2. Compliance: UL, FM.
3. Include:
   a. Externally operable thermal magnetic circuit breaker rated at 125 percent of nameplate current rating of motor.
   b. Across-the-line pump motor starter.
   c. Pressure switch with adjustable cut-in and cut-out points.
   d. Pilot lamp to indicate power to motor available.
   e. Pushbutton for manually starting motor.
   f. Operation mode selector (three position, hand-off-auto).
   g. Fuse blocks.
   h. Control power transformer as required.

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4. Enclosure: Sheet steel, NEMA 12, wall mountable design, with gasketed access door, threaded hubs for conduit entry, and bulkhead connector for connecting pressure sensor to pressure switch.
5. Provide timer to keep motor in operation for 5 minutes when started automatically.
6. Acceptable Manufacturer: Same as fire pump motor controller.

F. Interconnecting Water Piping:

1. Pipe: Galvanized Carbon steel, Schedule 40, ASTM 53, Type E, Grade A or B, ends to suit fittings.
2. Fittings: Wrought galvanized carbon steel, beveled ends for welding, ASME B16.9, ASTM A234, Grade WPB, wall thickness to match pipe, or UL listed, Victaulic 12/18/19/20/25/29/50/51/100/110, malleable iron with grooved ends for mechanically coupled joints, working pressure not less than that of couplings. Elbows long radius (1-1/2 D).
3. Couplings: Malleable iron, UL listed, Victaulic Style 75, good for working pressure not less than 350 psig with EPDM gasket, for joining pipe and fittings having grooved ends.
4. Flanges: Cast iron, ASME B16.1, ASTM A126 flat face, Class 125, or galvanized forged steel, ASTM A105, Class 150, ASME B16.5. Grooved adaptor flange, Victaulic Style 741, may be used in grooved end systems.
5. Gaskets: 1/8-inch-thick EPDM or equivalent.
6. Bolts: ASTM A307 Grade B, galvanized.
7. Nuts: ASTM A563 Grade A, galvanized.

G. Miscellaneous Piping:

1. Fuel Oil Vent and Fill: Copper, ASTM B88 Type K, with soldered joints using 95-5 solder.
2. Engine Exhaust: Carbon steel, standard weight, ASTM A53, Type E, Grade A or B with buttwelding fittings, ASME B16.9, ASTM A234 Grade WPB, wall thickness to match pipe; elbows long radius. Insulate exhaust piping, fittings, and silencer with fiberglass or calcium silicate insulation good for 650 degrees F continuous service and in thickness to limit surface temperature to 140 degrees F or less; finish with aluminum jacket.
3. Pipe Supports:
    a. Support and secure piping and valves with structural steel supports anchored to base.
    b. Support piping independently of equipment connections.
    c. Pipe supports welded directly to the pipe are unacceptable.

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H. Electrical Requirements:

1. Local Safety Disconnect Switches: Provide in NEMA enclosures non-fused safety disconnect switches for system equipment requiring local disconnects, each with the following minimum characteristics:
   a. Line terminal shields.
   b. Visible blades.
   c. Non-teasible, positive, quick-made, quick-break interrupter operating mechanism.
   d. Handle whose position is easily recognizable and can be padlocked in the “OFF” position.
   e. Defeatable door interlocks that prevents the door from opening when the operating handle is in the “ON” position.
   f. Factory installed ground lug.
   g. Cover viewing windows to observe on/off status.

I. Electrical Wire and Cable: Provide wire and cable as follows:

1. Signal Cables Type PLCC (power limited control cables):
   a. General: Rated 300 volts, 90 degrees C single pair (pr.) triad (tri.) or quad (qd.).
   b. Single Pr. Tri. or Qd.: No. 16 AWG, stranded copper conductors, twisted and covered with 100 percent aluminum–Mylar shield, with drain wire and overall PVC jacket.
   c. Multiple Pr. Tri. or Qd.: Same as single construction except No. 20 AWG conductors and an overall aluminum-Mylar shield in addition to individual shields.
   d. Analog Cables: Single Pr. Tri. or Qd.: No. 16 AWG, stranded copper conductors, twisted and covered with 100 percent aluminum-Mylar shield with drain wire and overall PVC jacket.
2. Power and Control Cables:
   a. Underwriters Type THWN-THHN (90 degrees C dry/75 degrees C wet) or XHHW (90 degrees C dry/75 degrees C wet) single conductor copper rated to 600 volts, for general use in dry and wet locations as branch circuits and control wiring up to 500 kcmils.
   b. Minimum size No. 12 AWG for power circuits and No. 14 AWG for control circuits.

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c. Color Coding: Provide color coding for power and control circuits as follows:

Voltage	PH/A	PH/B	PH/C	Neutral	Control	Ground
240 volts and below	Black	Red	Blue	White	Purple	Green
250-600	Yellow	Brown	Orange	Natural Gray	Purple	Green

3. For specified insulations and jackets not manufactured with integral colors use conductors with black insulation or jacket and color-coding tape.
4. Route control wiring and power wiring within Type IMC intermediate galvanized steel conduit, ANSI C80.1, UL 6, where wiring is not inside a cabinet or panel. Component connections may be flexible galvanized conduit, maximum length 2 feet 0 inches for each such connection.
5. Color code conductors entering boxes, cabinets, and other enclosures.
6. Provide wiring and wire markings in accordance with JIC Electrical Standards, the International Electrical Code, and NFPA 70. Mark and identify each wire or conductor in accordance with wiring diagram drawing designations at each terminal or connection.
7. Provide continuous green grounding conductor sized per NEC in raceways and bond to equipment ground terminator lugs.

J. Painting:

1. After successful completion of factory tests and before shipment, prime and paint exposed uncoated metal surfaces including fire pump casings, jockey pump casings, pump drives, pump drive controllers, fuel tanks, and structural members.
2. Prepare surfaces in accordance with recommendations of coating manufacturer.
3. Provide finish of semi-gloss enamel; provide compatible primer.
4. Provide red finish color for fire pump, jockey pump, drives, and controllers.
5. Include 2 quarts of finish for field touchup after installation.

PART 3 EXECUTION

3.01 INSTALLATION

A. Place, set, connect, and install complete fire pump system.

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3.02 FIELD QUALITY CONTROL

A. Provide services of manufacturer's field representative to supervise installation and assembly of items and equipment specified in this Section and assist and instruct installation personnel in correct sequence and procedures for installation.

B. Inspect jobsite 72 hours before shipment of packaged pump house module. Perform inspection accompanied by 'manufacturer's representative to assure field conditions compatible with packaged pump house.

C. Provide services of manufacturer's representative to 'conduct and document acceptance tests and startup of pumps and controllers specified in this Section and ensure conformance to acceptance requirements of NFPA 20.

3.03 START UP AND COMMISSIONING

A. Provide commissioning of the complete packaged pumping system, with equipment, materials, controls, and components as specified in this Section, by system manufacturer or his representative, including:

1. A check of proper installation by the installing contractor,
2. System check-out, adjustment,
3. Complete start-up.

B. This commissioning will occur only when hook-ups, tie-ins, and terminations have been completed and signed-off on the system manufacturer's start-up request form by the installer.

C. Provide to Owner written certification by manufacturer's representative that commissioning, installation, maintenance instruction, tests, adjustments, repairs, and startup are complete and that components are ready for continuous operation.

3.04 TRAINING

A. Provide instruction, by manufacturer's representative, of Owner's personnel in proper system operation and maintenance for systems and equipment furnished under this Section.

B. Provide personnel in direct employ of pumping system manufacturer for site instructional training.

C. Provide training on operation, maintenance, and troubleshooting of unit.

D. Provide instruction for minimum of 8 normal working hours.

E. Provide required educational materials for minimum of six personnel.

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F. Do not commence training until final turnover of operation and maintenance data to Owner.

G. Provide minimum of 10 days' notice of scheduled start of training

3.05 SUBMITTAL SCHEDULE

Item No.	Submittal Requirement	With Bid	As Indicated
21 30 01- 01	List of similar installations and Owner contact name.	X	Prior to delivery
21 30 01- 02	Statement of following minimum service requirements. (Specified time excludes travel): 1 man-days for training of Owner's personnel for startup, operating, and maintenance. 2 man-days for testing, certification, and commissioning of the installation. Emergency Repair Service: Within 4 hours of request, 24 hours per day, 7 days per week, throughout the warranty period.		Per construction schedule
21 30 01- 03	Detailed installation shop drawings of the complete pump system. Show information required by NFPA 20 for working plans and include: Pumps and drivers, jockey pumps. Installation dimensions and cut lengths for piping. Valves, fittings, and accessories. Product data, including manufacturers' catalog data and details on pumps, drivers, controllers, piping, and valving. Bill of materials showing make, model, part number, and options for pumps, drivers, controllers, valves. Anchor bolt size and location.		Prior to delivery

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Item No.	Submittal Requirement	With Bid	As Indicated
21 30 01- 04	Descriptions and schematics for sensing lines and controllers. Controller wiring interconnection and schematic, motor horsepower, and power supply voltage. Electric motor HP, FLA, volts, phase, Hz. Pump Start/Stop/Timer Setpoints. Total connected electrical load, kW or HP.		With installation shop drawings
21 30 01- 05	Certified fire pump performance curve.		Before date of Substantial Completion
21 30 01- 06	Factory test reports.		Before date of Substantial Completion
21 30 01- 07	Operation and maintenance manuals, final drawings, and final calculations. Setting and installation instructions.		With record documents
21 30 01- 08	Spare parts list		With operations and maintenance manuals

END OF SECTION

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SECTION 22 05 48
VIBRATION ISOLATION AND SEISMIC CONTROL
FOR PLUMBING PIPING AND EQUIPMENT

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American National Standards Institute (ANSI).
2. ASTM International (ASTM).
   a. A36/A36M, Specification for Carbon Structural Steel.
   b. E488, Standard Test Methods for Strength of Anchors in Concrete and Masonry Elements.
3. American Welding Society (AWS): D1.1/D1.1M, Structural Welding Code—Steel.
4. Vibration Isolation and Seismic Control Manufacturers Association (VISCMA).

1.02 DEFINITIONS

A. AHJ: Authority Having Jurisdiction.

B. EPDM: Ethylene-Propylene-Diene Monomer.

C. OSHPD: Office of Statewide Health Planning and Development, for the State of California.

D. Withstand: Unit will remain in place without separation of any parts from the device when subjected to seismic forces specified.

1.03 DESIGN REQUIREMENTS

A. Seismic Control:

1. Provide seismic control as required to maintain integrity of plumbing piping, and equipment installed in this Project, so they will “withstand” seismic forces.
2. Design shall comply with requirements of this specification, applicable codes, and requirements of Section 01 61 00, Common Product Requirements.
3. Design, size, and install for piping and equipment throughout facility, whether shown or not.

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4. Designed by a registered professional engineer in the state where the Work is to be installed.

1.04 SUBMITTALS

A. Action Submittals:

1. Shop Drawings, Vibration Isolators:
   a. Basic equipment layout, length and width, installed operating weights of equipment to be isolated and distribution of weight at isolation points.
   b. Product Data:
      1) Manufacturer's product data including details of materials, construction, dimensions of individual components, installation details, and finishes.
      2) Schedule of vibration isolator type with location and static and dynamic load on each.
      3) Vibration Isolation Base Details:
         a) Detail fabrication, including anchorages and attachments to structure and to supported equipment.
         b) Include auxiliary motor slides and rails, base weights, equipment static loads, power transmission, component misalignment, and cantilever loads.
2. Shop Drawings, Seismic Control Components:
   a. Include, as a minimum, basic equipment layout, length and width, installed operating weights of equipment to be under seismic control and distribution of weight.
   b. Signed and sealed by a Professional Engineer registered in the state where the Project is located.
   c. Include, as a minimum, a tabulation of design data for each snubber, including specific anchorage details.
   d. Detail fabrication and attachment of seismic restraints and snubbers. Show anchorage details and indicate quantity, diameter, and depth of penetration of anchors.
   e. Product Data:
      1) Manufacturer's product data including details of materials, construction, dimensions of individual components, installation details, and finishes.
      2) Schedule of seismic control component type with location and static and dynamic load on each.
      3) Interlocking Snubbers: Include load deflection curves up to 1/2-inch deflection in x, y, and z planes.

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B. Informational Submittals:

1. Manufacturer's Installation Instructions: Indicate special procedures and setting dimensions.
2. Certifications:
    a. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements.
    b. Manufacturer's Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers' Field Services.
    c. Welding Certificates: Welding procedures and personnel.
    d. Manufacturer's Seismic Certification:
        1) Certification that specified equipment will withstand seismic forces. Include the following:
            a) Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculations.
            b) Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
            c) Detailed description of equipment anchorage devices on which certification is based and their installation requirements.
3. Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.

1.05 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M.

B. Isolation materials, flexible connectors, and seismic restraints shall be same manufacturer. Select and certify using published or factory certified data.

C. Seismic Control:

1. Designer Qualifications:
    a. Professional Engineer registered in the state where Project resides.
    b. Minimum of 5 years' work experience certifying seismic snubber and anchorage details.
2. Components shall bear anchorage pre-approval "R" number, from OSHPD or other agency acceptable to AHJ, showing maximum seismic restraint ratings.
3. Horizontal and vertical load testing and analysis shall be performed according to OSHPD requirements.

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PART 2 PRODUCTS

2.01 VIBRATION ISOLATION

A. General:

1. Provide for plumbing piping and equipment as identified by this Specification.
2. Select in accordance with equipment or pipe weight distribution to produce reasonably uniform deflections.
3. Springs: Minimum horizontal stiffness equal to 75 percent vertical stiffness, with working deflection between 30 percent and 60 percent of maximum deflection.

B. Elastomeric Pad:

1. Oil-resistant and water-resistant elastomer or natural rubber waffle pads, arranged in single or multiple layers, molded with a nonslip pattern.
2. Waffle pads bonded each side of minimum 1/4-inch-thick galvanized steel separator plate.
3. Height of waffle ribs shall not exceed 0.7 times width.
4. Maximum Loading: 60 psi.
5. Minimum Single Layer Thickness: 1/4 inch.
6. Separator plate of sufficient stiffness for uniform loading over pad area.
7. Factory cut to size that matches requirements of supported equipment.
8. Waffle Pad Material: Standard neoprene or natural rubber.
9. Number of Layers: As required to support equipment load; refer to manufacturer's data for load capacities.

C. Elastomeric Mount:

1. Double-deflection type, with molded, oil-resistant rubber or neoprene isolator elements.
2. Factory-drilled, encapsulated top plate for bolting to equipment.
3. Baseplate for bolting to structure.

D. Open Spring Isolator:

1. Freestanding, laterally stable, open-spring isolators.
2. Outside Spring Diameter: Not less than 80 percent of compressed height of spring at rated load.
3. Minimum Additional Travel: 50 percent of required deflection at rated load.
4. Lateral Stiffness: 80 percent minimum of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

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6. Baseplate:
    a. Factory drilled for bolting to structure and bonded to 1/4-inch-thick rubber isolator pad attached to baseplate underside.
    b. Limit floor load to 100 psig.
7. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

E. Restrained Spring Isolator:

1. Freestanding, steel, open-spring isolators with seismic restraint.
2. Housing: Steel with resilient vertical-limit stops to prevent spring extension because of wind loads or if weight is removed; factory-drilled baseplate bonded to 1/4-inch-thick elastomeric isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.
3. Outside Spring Diameter: 80 percent minimum of compressed height of spring at rated load.
4. Minimum Additional Travel: 50 percent of required deflection at rated load.
5. Lateral Stiffness: 80 percent minimum of the rated vertical stiffness.
6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

F. Elastomeric Hanger:

1. Double-deflection type.
2. Molded, oil-resistant rubber or neoprene isolator elements bonded to steel housing.
3. Threaded connections for hanger rods.

G. Spring Hanger:

1. Combination coil-spring and elastomeric-insert hanger with spring and insert in compression.
2. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
3. Outside Spring Diameter: 80 percent minimum of compressed height of spring at rated load.
4. Minimum Additional Travel: 50 percent of required deflection at rated load.
5. Lateral Stiffness: 80 percent minimum of rated vertical stiffness.
6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

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7. Elastomeric Element:
    a. Molded, oil-resistant rubber or neoprene.
    b. Steel washer-reinforced cup to support spring and bushing projecting through bottom of frame.

H. Thrust Limit:

1. Combination coil spring and elastomeric insert with spring and insert in compression and with a load stop.
2. Rod and angle-iron brackets for attaching to equipment.
3. Frame: Steel, fabricated for connection to threaded rods and to allow for a maximum of 30 degrees of angular rod misalignment without binding or reducing isolation efficiency.
4. Outside Spring Diameter: 80 percent minimum of compressed height of spring at rated load.
5. Minimum Additional Travel: 50 percent of required deflection at rated load.
6. Lateral Stiffness: 80 percent minimum of rated vertical stiffness.
7. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
8. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
9. Coil Spring: Factory set and field adjustable for a maximum of 1/4-inch movement at start and stop.

I. Manufacturers:

1. Mason Industries, Inc.
2. Kinetics Noise Control, Inc.
3. California Dynamics Corp.
4. Isolation Technology, Inc.
5. M.W. Sausse & Co., Inc. (VIBREX).
6. Vibration Eliminator Co., Inc.
7. Vibration Isolation Co., Inc.
8. The VMC Group.

2.02 EQUIPMENT BASES

A. Structural Steel Base:

1. Factory-fabricated, welded, structural steel base and rail.
2. Design Requirements:
    a. Lowest possible mounting height with not less than 1-inch clearance above floor.
    b. Provide equipment anchor bolts and auxiliary motor slide bases or rails.
    c. Provide supports for suction and discharge elbows for pumps.

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3. Structural Steel:
    a. Steel shapes, plates, and bars complying with ASTM A36/A36M.
    b. Bases shall have shape to accommodate supported equipment.
4. Support Brackets: Factory-welded steel angles on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.

B. Concrete Inertia Base:

1. Factory-fabricated, welded, structural steel base and rail ready for cast-in-place concrete.
2. Design Requirements:
    a. Lowest possible mounting height with not less than 1-inch clearance above floor.
    b. Provide equipment anchor bolts and auxiliary motor slide bases or rails.
    c. Provide supports for suction and discharge elbows for pumps.
3. Structural Steel:
    a. Steel shapes, plates, and bars complying with ASTM A36/A36M.
    b. Bases shall have shape to accommodate supported equipment.
4. Support Brackets: Factory-welded steel angles on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.
5. Fabrication:
    a. Fabricate steel templates to hold equipment anchor bolt sleeves and anchors in place during placement of concrete.
    b. Obtain anchor bolt templates from supported equipment manufacturer.
6. Concrete: 3,000 psi.

C. Manufacturers:

1. Mason Industries, Inc.
2. Kinetics Noise Control, Inc.
3. California Dynamics Corp.
4. M.W. Sausse & Co., Inc. (VIBREX).
5. Thybar Inc.
6. Vibration Eliminator Co., Inc.
7. Vibration Isolation Co., Inc.
8. The VMC Group.

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2.03 FLEXIBLE CONNECTORS

A. Flexible Pipe Connectors:

1. Braided Nonferrous: For nonferrous piping systems, provide bronze hose covered with bronze wire braid with copper tube ends or bronze flanged ends, braze-welded to hose.
2. Braided Stainless Steel: For ferrous piping, provide stainless steel hose covered with Type 304 stainless steel wire braid with NPT steel nipples or 150-psi ANSI flanges, welded to hose.
3. Rubber:
   a. Neoprene or EDPM construction consisting of multiple piles of nylon tire cord fabric and elastomer, molded and cured in hydraulic rubber presses.
   b. Straight or elbow connector as indicated on Drawings, rated at 125 psi at 220 degrees F.
4. Manufacturers:
   a. Mason Industries, Inc.
   b. General Rubber.
   c. Kinetics Noise Control, Inc.

2.04 SEISMIC RESTRAINTS

A. Resilient Isolation Washers and Bushings: One-piece, molded neoprene, having a durometer 40, plus or minus 5, with a flat washer face.

B. Seismic Snubbers: Factory fabricated using welded structural steel shapes and plates, anchor bolts, and replaceable resilient isolation washers and bushings.

C. Restraining Cables: Galvanized steel aircraft cables with end connections made of steel assemblies that swivel to final installation angle and utilize two clamping bolts for cable engagement.

D. Anchor Bolts:

1. Seismic-rated, drill-in, and stud-wedge or female-wedge type.
2. Select anchor bolts with strength required for anchor and as tested according to ASTM E488.

E. Manufacturers:

1. California Dynamics Corp.
2. Kinetics Noise Control, Inc.
3. Loos & Co., Inc.; Cableware Technology Division.
4. Mason Industries, Inc.
5. M.W. Sausse & Co., Inc. (VIBREX).

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6. TOLCO Incorporated.
7. Unistrut Diversified Products Co.; Wayne Manufacturing Division.
8. Vibration Eliminator Co., Inc.
9. Vibration Isolation Co., Inc.
10. The VMC Group.

2.05 SHOP/FACTORY FINISHING

A. Manufacturer's standard paint applied to factory-assembled and factory-tested equipment, before shipping.

1. Powder coating on springs and housings.
2. Electro-galvanized hardware.
3. Hot-dip galvanized metal components for exterior use.
4. Baked enamel coat metal components for interior use.

B. Color-code or otherwise mark vibration isolation and seismic control devices to indicate capacity range.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine areas and equipment to receive vibration isolation and seismic control devices for compliance with requirements, installation tolerances, and other conditions affecting performance.

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. General:

1. Install products in accordance with manufacturers' written instructions.
2. Connect wiring to isolated equipment with flexible hanging loop.
3. Install thrust limits at centerline of thrust, symmetrical on either side of equipment.
4. Locate isolation hangers as near overhead support structure as possible.

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B. Vibration Isolators:

1. Install spring hangers without binding.
2. On closed spring isolators, adjust so side stabilizers are clear under normal operating conditions.

C. Equipment Bases:

1. Adjust equipment level.
2. Bases with seismic snubbers shall have snubbers located close to isolators.
3. Structural Steel Bases: Set steel bases for 1-inch clearance between housekeeping pad and base.
4. Concrete Inertial Bases:
    a. Set concrete inertia bases for 2-inch clearance between housekeeping pad and base.
    b. Fill concrete inertia bases, after installing base frame, with concrete; trowel to a smooth finish.

D. Flexible Connectors: Prior to making piping connections to equipment with operating weights substantially different from installed weights, block up equipment with temporary shims to final height. When full load is applied, adjust isolators to load to allow shim removal.

E. Seismic Restraint Devices:

1. Notify local representative of seismic restraint materials manufacturer prior to installing seismic restraint devices.
2. No rigid connections between equipment and building structure shall be made which degrades seismic restraint system herein specified.
3. Electrical conduit to restrained equipment shall be looped to allow free motion of equipment without damage to electrical wiring.
4. Install seismic snubbers on isolated equipment.
5. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.
6. Install restraining cables at each trapeze and individual pipe hanger. At trapeze anchor locations, shackle piping to trapeze. Install cables so they do not bend across sharp edges of adjacent equipment or building structure.
7. Install steel angles or channel, sized to prevent buckling, clamped with ductile-iron clamps to hanger rods for trapeze and individual pipe hangers.
8. At trapeze anchor locations, shackle piping and equipment to trapeze.
9. Install resilient bolt isolation washers on equipment anchor bolts.

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10. Upon completion of seismic restraint material installation and before startup of restrained equipment, clean debris from beneath protected equipment, leaving equipment free to contact snubbers.

3.03 FIELD QUALITY CONTROL

A. Testing:

1. Conduct the following field quality-control testing:
   a. Isolator deflection.
   b. Isolator seismic-restraint clearance.
   c. Snubber minimum clearances.

B. Seismic Control Component Inspection:

1. Conduct periodic inspections of material installation with assistance of manufacturer's representative. Report in writing deviations from good installation practice.
2. Upon completion of seismic restraint device installation inspect completed system with assistance of manufacturer's representative. Report in writing installation errors, improperly selected snubber devices, or other fault in the system that could affect performance of the system.

3.04 ADJUSTING

A. Vibration Isolation Devices:

1. Adjust isolators after piping systems have been filled and equipment is at operating weight.
2. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height.
3. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.
4. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4-inch movement during start and stop.
5. Adjust isolators to ensure units do not exceed rated operating deflections or bottom out under loading, and are not short circuited by other contacts or bearing points.
6. Adjust leveling devices as required to distribute loading uniformly on isolators. Shim units as required where leveling devices cannot be used to distribute loading properly.

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B. Seismic Control Components:

1. Adjust snubbers according to manufacturer's written recommendations.
2. Adjust seismic restraints to permit free movement of equipment within normal mode of operation.
3. Torque anchor bolts according to equipment manufacturer's written recommendations to resist seismic forces.

3.05 CLEANING

A. After completing equipment installation, inspect vibration isolation and seismic control devices. Remove paint splatters and other spots, dirt, and debris.

3.06 SUPPLEMENTS

A. The supplement listed below, following "End of Section," is a part of this Specification:

1. Section 22 05 48.01, Vibration Isolation Schedule for Plumbing Piping and Equipment.

END OF SECTION

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VIBRATION ISOLATION SCHEDULE FOR PLUMBING PIPING AND EQUIPMENT 22 05 48.01

ISOLATED EQUIPMENT	DESCRIPTION						
	TAG NUMBERS		WH-07				
	LOCATION		GROUND				
VIBRATION ISOLATOR	TYPE		NONE				
	MINIMUM DEFLECTION	INCH					
EQUIPMENT BASE	TYPE		NONE				
FLEXIBLE CONNECTOR	TYPE		FLEX PIPE CONN - BRAIDED SST				
	MINIMUM DEFLECTION	INCH					
ISOLATED PIPE	DESCRIPTION						
	TAG NUMBERS						
	LOCATION						
VIBRATION ISOLATOR	TYPE						
	MINIMUM DEFLECTION	INCH					

REMARKS

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SECTION 22 07 00
PLUMBING PIPING INSULATION

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Society of Heating, Refrigerating & Air-Conditioning Engineers Inc. (ASHRAE): 90.1, Energy-Efficient Design of New Buildings except Low-Rise Residential Buildings.
2. ASTM International (ASTM):
   a. B209, Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
   b. C533, Standard Specification for Calcium Silicate Block and Pipe Thermal Insulation.
   c. C534, Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.
   d. C547, Standard Specification for Mineral Fiber Pipe Insulation.
3. National Fire Protection Association (NFPA): 255, Standard Method of Test of Surface Burning Characteristics of Building Materials.
4. Underwriters Laboratories, Inc. (UL).

1.02 SUBMITTALS

A. Action Submittals: Product description, include list of materials, thickness for each service scheduled, and locations.

B. Informational Submittals:

1. Proof of compliance for test of products for fire rating, corrosiveness, and compressive strength.
2. Manufacturer’s installation instructions.

1.03 QUALITY ASSURANCE

A. Materials furnished under this Specification shall be standard, cataloged products, new and commercially available, suitable for service requiring high performance and reliability with low maintenance, and free from all defects.

B. Provide materials by firms engaged in the manufacture of insulation products of the types and characteristics specified herein, whose products have been in use for not less than 5 years.

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C. UL Listing or satisfactory certified test report from an approved testing laboratory is required to indicate fire hazard ratings for materials proposed for use do not exceed those specified.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Manufacturer's Stamp or Label:

1. Every package or standard container of insulation, jackets, cements, adhesives and coatings delivered to Site shall have manufacturer's stamp or label attached, giving name of manufacturer, brand, and description of material.
2. Insulation packages and containers shall be marked "asbestos-free."

PART 2 PRODUCTS

2.01 GENERAL

A. Insulation exterior shall be cleanable, grease-resistant, nonflaking, and nonpeeling.

B. Insulation shall conform to referenced publications and specified temperature ranges and densities in pounds per cubic foot.

C. Insulation for fittings, flanges, and valves shall be premolded, precut, or job-fabricated insulation of same thickness and conductivity as used on adjacent piping.

D. Fire Resistance:

1. Insulation, adhesives, vapor barrier materials and other accessories, except as specified herein, shall be noncombustible.
2. Use no fugitive or corrosive treatments to impart flame resistance.
3. Flame proofing treatments subject to deterioration due to effects of moisture or high humidity are not acceptable.
4. Materials including facings, mastics, and adhesives, shall have fire hazard rating not to exceed 25 for flame spread without evidence of continued progressive combustion, and 50 for smoke, developed as per tests conducted in accordance with NFPA 255 methods.
5. Materials exempt from fire-resistant rating:
   a. Nylon anchors.
   b. Treated wood inserts.

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6. Materials exempt from fire-resistant rating when installed in outside locations, buried, or encased in concrete:
    a. Polyurethane insulation.
    b. PVC casing.
    c. Fiberglass-reinforced plastic casing.

2.02 PIPE INSULATION

A. Type P1—Fiberglass (ASTM C547, Type 1 (Minus 20 Degrees F to 500 Degrees F):

1. Fiberglass, UL-rated, preformed, sectional rigid, minimum 4 pounds per cubic foot (PCF) density, K factor 0.23 maximum at 75 degrees F mean, with factory-applied all-service jacket (ASJ) composed of reinforced kraft paper and aluminum foil laminate. Jacket shall have self-sealing lap to facilitate closing longitudinal and end joints.
2. Manufacturers and Products:
    a. CertainTeed; Preformed Pipe Insulation.
    b. Johns Manville; Micro-Lok AP-T.
    c. Owens/Corning Fiberglas Pipe Insulation.
    d. Knauf Pipe Insulation; Crown Pipe Insulation.

B. Type P1A—Fiberglass, ASTM C547, Type 2, 650 Degrees F, Maximum; Class 3, 850 Degrees F, Maximum:

1. Fiberglass, minimum 5 PCF density, K factor 0.34 maximum at 300 degrees F mean, with factory-applied all-weather jacket (AWJ) for temperatures ambient to 850 degrees F.
2. Manufacturers and Products:
    a. CertainTeed; Preformed Pipe Insulation.
    b. Johns Manville; Micro Lok.
    c. Knauf; Rocksil Mattress.
    d. Owens/Corning; Fiberglas Pipe Insulation.

C. Type P2—Calcium Silicate (ASTM C533, 1,200 Degrees F, Maximum):

1. Calcium silicate, minimum 12 PCF density, K factor 0.46 maximum at 300 degrees F mean, without factory-applied jacket.
2. Manufacturers and Products:
    a. Owens/Corning Fiberglass; Kaylo 10.
    b. Johns Manville; Thermo-12 Gold.
    c. Calsilite; 1,200-degree thermal insulation.

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D. Type P3—Elastomeric (ASTM C534, Minus 40 Degrees F to 220 Degrees F):

1. Flexible, closed cell elastomeric.
2. Nominal 6 PCF density, K factor 0.27 maximum at 75 degrees F mean.
3. Water Vapor Transmission: 0.1 perm-inch, or less.
4. Manufacturers and Products:
    a. Armacell; AP Armaflex.
    b. Nomaco; K-Flex LS.
    c. Rubatex; R-180-FS.

E. Type P4—Cellular Glass:

1. Cellular glass, closed cell, rigid, nominal 8 PCF density, maximum K factor 0.33 at 75 degrees F mean, with factory-applied FSK (foil-scrim-kraft) vapor barrier jacket, for temperatures to 900 degrees F.
2. Manufacturer and Product: Pittsburgh-Corning; Foamglas.

2.03 INSULATION FINISH SYSTEMS

A. Type F1—PVC:

1. Polyvinyl chloride (PVC) jacketing, white, for straight run piping and fitting locations, temperatures to 159 degrees F.
2. Manufacturers and Products:
    a. Johns Manville; Zeston.
    b. Ceel-Co; 550.

B. Type F2—Paint:

1. Acrylic latex paint, white, and suitable for outdoor use.
2. Manufacturers and Products:
    a. Armstrong; WB Armaflex finish.
    b. Rubatex; 374, white finish.

C. Type F3—Aluminum:

1. Aluminum Roll Jacketing: For straight run piping, wrought aluminum Alloy 3003, 5005, 1100 or 3105 to ASTM B209 with H-14 temper, minimum 0.016-inch thickness, with smooth mill finish.
2. Moisture Barrier: Provide factory applied moisture barrier, consisting of 40-pound kraft paper with 1-mil-thick low-density polyethylene film, heat and pressure bonded to inner surface of the aluminum jacketing.
3. Fitting Covers: Material as for aluminum roll jacketing, premolded, one or two piece covers, which includes elbows, tee/valves, end caps, mechanical line couplings, and specialty fittings.
4. Manufacturer and Product: RPR Products; INSUL-MATE.

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D. Type F4—Ceramic:

1. Insulating duct coating, fluid-applied coating with ceramic insulating particles.
2. Manufacturer and Product: ASTEC, by Insulating Coatings Corp., Inverness, FL.

PART 3 EXECUTION

3.01 INSTALLATION OF INSULATION

A. Install insulation products in accordance with manufacturer's written instructions, and in accordance with recognized industry practices.

B. Apply insulation over clean, finish painted, and dry surfaces.

C. Install insulation after piping system has been pressure tested and leaks corrected.

D. Use insulating cements, lagging adhesives, and weatherproof mastics recommended by insulation manufacturer.

E. Install insulation materials with smooth and even surfaces. Insulate each continuous run of piping with full-length units of insulation, with a single cut piece to complete the run. Do not use cut pieces of scraps abutting each other.

F. Butt insulation joints firmly together to ensure a complete and tight fit over surfaces to be covered.

G. Maintain integrity of vapor-barrier jackets on pipe insulation, and protect to prevent puncture or other damage. Seal open ends of insulation with mastic. Sectionally seal butt ends of chilled water and condensate drain piping insulation at fittings with white vapor barrier coating.

H. Cover valves, flanges, fittings, and similar items in each piping system with equivalent thickness and composition of insulation as applied to adjoining pipe run. Install factory molded, precut or job-fabricated units. Finish cold pipe fittings with white vapor barrier coating and hot piping with white vinyl acrylic mastic, both reinforced with glass cloth.

I. Extend piping insulation without interruption through walls, floors, and similar piping penetrations, except where otherwise indicated.

J. Install protective metal shields and foamglass inserts where pipe hangers bear on outside of insulation.

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K. Insulation on piping that is to be heat traced shall be installed after installation of heat tape.

L. Insulate valve bodies, flanges, and pipe couplings.

M. Insulate and vapor seal hangers, supports, anchors, and other piping appurtenances that are secured directly to cold surfaces.

N. Do not insulate flexible pipe couplings and expansion joints.

O. Do not allow insulation to cover nameplates or code inspection stamps.

P. Install removable insulation sections on devices that require access for maintenance of equipment or removal, such as unions and strainer end plates.

Q. Connection to Existing Piping: Cut back existing insulation to remove portion damaged by piping revisions. Install new insulation.

R. Cold Surfaces: Provide continuous vapor seal on insulation on cold surfaces where vapor barrier jackets are used.

S. Placement:

1. Slip insulation on pipe or tubing before assembly, when practical, to avoid longitudinal seams.
2. Insulate valves and fittings with sleeved or cut pieces of same material.
3. Seal and tape joints.

T. Insulation at Hangers and Supports: Install under piping, centered at each hanger or support.

U. Vapor Barrier:

1. Provide continuous vapor barrier at joints between rigid insulation and pipe insulation.
2. Install vapor barrier jackets with pipe hangers and supports outside jacket.
3. Do not use staples and screws to secure vapor sealed system components.

3.02 INSTALLATION OF INSULATION FINISH SYSTEMS

A. Use a continuous friction type joint to hold jacket in-place, providing positive weatherproof seal over entire length of jacket.

B. Secure circumferential joints with preformed snap straps containing weatherproof sealant.

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C. On exterior piping, apply coating over insulation and vapor barrier to prevent damage when aluminum fitting covers are installed.

D. Do not use screws or rivets to fasten the fitting covers.

E. Install removable prefabricated aluminum covers on exterior flanges and unions.

F. Caulk and seal exterior joints to make watertight.

3.03 INSULATION APPLICATIONS

A. Cold Water (W1/W2):

1. Type P3, elastomeric.
2. 1-inch thickness for all pipe sizes.

B. Potable Hot Water (W1):

1. Type P1, fiberglass.
2. 1-inch thickness for all pipe sizes.

C. Pipe Hangers:

1. Type P1, Fiberglass: UL-rated, preformed rigid pipe insulation inserts of thickness equal to adjoining insulation, 10 inches in length, with factory-applied, vinyl-coated and embossed vapor barrier jacket with self-sealing lap.
2. Type P3, Elastomeric: Rigid insulation section with 9-inch-long, 16-gauge galvanized steel saddle.

3.04 INSULATION FINISH APPLICATIONS

A. Piping Insulation (Concealed Areas): Factory finish.

B. Piping Insulation (Exposed to View, Indoors): Type F1, PVC.

C. Piping Insulation (Outdoors):

1. Type F2, paint (for use with Type P3, elastomeric).
2. Type F3, aluminum.

D. Apply coating of insulating cement where needed to obtain smooth and continuous appearance.

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3.05 FIELD QUALITY CONTROL

A. Test factory-applied materials assembled. Field-applied materials may be tested individually.

END OF SECTION

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SECTION 22 10 01
PLUMBING PIPING AND ACCESSORIES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American National Standards Institute (ANSI).
2. American Public Works Association (APWA): Uniform Color Code.
3. American Society of Sanitary Engineering (ASSE):
   a. 1010, Performance Requirements for Water Hammer Arresters.
   b. 1050, Performance Requirements for Stack Air Admittance Valves for Sanitary Drainage Systems.
   c. 1070, Performance Requirements for Water Temperature Limiting Devices.
4. ASTM International (ASTM):
   a. A47/A47M, Standard Specification for Ferritic Malleable Iron Castings.
   b. A53/A53M, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
   c. A74, Standard Specification for Cast Iron Soil Pipe and Fittings.
   d. A105/A105M, Standard Specification for Carbon Steel Forgings for Piping Applications.
   e. A126, Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
   f. A179/A179M, Standard Specification for Seamless Cold-Drawn Low-Carbon Steel Heat-Exchanger and Condenser Tubes.
   g. A181/A181M, Standard Specification for Carbon Steel Forgings, for General-Purpose Piping.
   h. A193/A193M, Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
   i. A194/A194M, Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
   j. A197/A197M, Standard Specification for Cupola Malleable Iron.
   k. A234/A234M, Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service.
   l. A307, Standard Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength.
   m. A351/A351M, Standard Specification for Castings, Austenitic, for Pressure-Containing Parts.

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n. A518/A518M, Standard Specification for Corrosion-Resistant High-Silicon Iron Castings.
o. A536, Standard Specification for Ductile Iron Castings.
p. A563, Standard Specification for Carbon and Alloy Steel Nuts.
q. A861, Standard Specification for High-Silicon Iron Pipe and Fittings.
r. A888, Standard Specification for Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications.
s. B32, Standard Specification for Solder Metal.
t. B61, Standard Specification for Steam or Valve Bronze Castings.
u. B62, Standard Specification for Composition Bronze or Ounce Metal Castings.
v. B75/B75M, Standard Specification for Seamless Copper Tube.
w. B88, Standard Specification for Seamless Copper Water Tube.
x. B98/B98M, Standard Specification for Copper-Silicon Alloy Rod, Bar, and Shapes.
y. B127, Standard Specification for Nickel-Copper Alloy (UNS N04400) Plate, Sheet, and Strip.
z. B139/B139M, Standard Specification for Phosphor Bronze Rod, Bar, and Shapes.
aa. B164, Standard Specification for Nickel-Copper Alloy Rod, Bar, and Wire.
bb. B194, Standard Specification for Copper-Beryllium Alloy Plate, Sheet, Strip, and Rolled Bar.
cc. B306, Standard Specification for Copper Drainage Tube (DWV).
dd. C564, Standard Specification for Rubber Gaskets for Cast Iron Soil Pipe and Fittings.
ee. C1277, Standard Specification for Shielded Couplings Joining Hubless Cast Iron Soil Pipe and Fittings.
ff. C1460, Standard Specification for Shielded Transition Couplings for use with Dissimilar DWV Pipe and Fittings Above Ground.
gg. C1540, Standard Specification for Heavy Duty Shielded Couplings Joining Hubless Cast Iron Soil Pipe and Fittings.
hh. D1784, Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.
ii. D1785, Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.
jj. D2000, Standard Classification System for Rubber Products in Automotive Applications.
kk. D2239, Standard Specification for Polyethylene (PE) Plastic Pipe (SIDR-PR) Based on Controlled Inside Diameter.
ll. D2466, Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.

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mm. D2564, Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems.
nn. D2683, Standard Specification for Socket-Type Polyethylene Fittings for Outside Diameter-Controlled Polyethylene Pipe and Tubing.
oo. D2855, Standard Practice for Making Solvent-Cemented Joints with Poly(Vinyl Chloride) (PVC) Pipe and Fittings.
pp. D3035, Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter.
qq. D3261, Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing.
rr. D3350, Standard Specification for Polyethylene Plastics Pipe and Fittings Materials.
ss. E438, Standard Specification for Glasses in Laboratory Apparatus.
tt. F656, Standard Specification for Primers for Use in Solvent Cement Joints of Poly(Vinyl Chloride) (PVC) Plastic Pipe and Fittings.
uu. F714, Standard Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter.
vv. F1412, Standard Specification for Polyolefin Pipe and Fittings for Corrosive Waste Drainage Systems.
ww. Distribution Pipe and Tubing.

5. American Water Works Association (AWWA):
   a. C104/A21.4, Standard for Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water.
   b. C110/A21.10, Standard for Ductile-Iron and Gray-Iron Fittings.
   c. C111/A21.11, Standard for Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
   d. C115/A21.15, Standard for Flanged Ductile-Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges.
   e. C151/A21.51, Standard for Ductile-Iron Pipe, Centrifugally Cast.
   f. C203, Coal-Tar Protective Coatings and Linings for Steel Water Pipelines, Enamel and Tape, Hot-Applied.
   g. C207, Steel Pipe Flanges for Waterworks Service - Sizes 4 In. Through 144 In. (100 mm Through 3,600 mm).
   h. C606, Grooved and Shouldered Joints.
   i. C651, Disinfecting Water Mains.
6. Cast Iron Soil Pipe Institute (CISPI):
   a. 301, Standard Specification for Hubless Cast Iron Pipe and Fittings for Sanitary and Storm Drain, Waste, and Vent Piping Applications.
   b. 310, Specification for Couplings for Use in Connection with Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Strom Drain, Waste, and Vent Piping Applications.

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7. NSF International (NSF):
    a. NSF/ANSI 61, Drinking Water System Components - Health Effects.
    b. NSF/ANSI 372, Drinking Water System Components - Lead Content.
8. Plumbing and Drainage Institute (PDI): WH 201, Water Hammer Arresters Standard.

1.02 DESIGN REQUIREMENTS

A. Where pipe diameter, thickness, pressure class, pressure rating, or thrust restraint is not shown or specified, design piping system in accordance with the following:

1. Building Service Piping: ASME B31.9, as applicable.
2. 2015 Uniform Plumbing Code.

1.03 SUBMITTALS

A. Action Submittals:

1. Product data sheets.
2. Shop Drawings:
    a. Show Contractor recommended changes in location of fixtures or equipment.
    b. Anchorage and bracing drawings and data sheets, as required by Section 01 88 15, Anchorage and Bracing.
3. Isometric riser diagrams.

B. Informational Submittals:

1. Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Changes in location of equipment or piping that affect connecting or adjacent work, before proceeding with the work.
3. Complete list of products proposed for installation.
4. Test records produced during testing.

PART 2 PRODUCTS

2.01 GENERAL

A. Components and Materials in Contact with Water for Human Consumption: Comply with the requirements of the Safe Drinking Water Act and other applicable federal, state, and local requirements. Provide certification by manufacturer or an accredited certification organization recognized by the Authority Having Jurisdiction that components and materials comply with the

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maximum lead content standard in accordance with NSF/ANSI 61 and NSF/ANSI 372.

1. Use or reuse of components and materials without a traceable certification is prohibited.

2.02 PIPING

A. Piping Schedule: Refer to Article Supplements.

B. Piping Material: Refer to Piping Data Sheet(s), Article Supplements.

2.03 HOSE VALVES AND HYDRANTS

A. NFWH-1, Wall Hydrant:

1. Nonfreeze exposed with chrome-plated face, integral vacuum breaker, bronze casing, T-handle key, and 3/4-inch inlet and hose connection.
2. Manufacturers and Products:
   a. J. R. Smith; Figure 5609QT.
   b. Josam; 71050 Series.

B. HB-1, Hydrant:

1. Sill faucet with removable T-handle, polished chrome finish, and 3/4-inch inlet and hose connection.
2. Manufacturers and Products:
   a. Chicago; No. 387, with No. E27 vacuum breaker.
   b. Acorn; No. 8121.

C. V200, HV-1, Hose Valve:

1. Cast bronze globe valve, 1-1/2-inch size, with NPT screwed ends, union bonnet, rising stem, Teflon disc, hand wheel, and NPT by NST hose thread adapter outlet connection.
2. Rated 150-pound SWP, 300-WOG.
3. Manufacturers and Products:
   a. Nibco; Catalog No. T-235-Y, Angle No. T-335-Y.
   b. Crane Co.; Catalog No. 7TF, Angle No. 17TF.

D. V200, HV-2, Hose Valve:

1. Cast bronze globe valve, 2-inch size, with NPT screwed ends, union bonnet, rising stem, Teflon disc, hand wheel, and NPT by NST hose thread adapter outlet connection.
2. Rated 150-pound SWP, 300-WOG.

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3. Manufacturers and Products:
    a. Nibco; Catalog No. T-235-Y, Angle No. T-335-Y.
    b. Crane Co.; Catalog No. 7TF, Angle No. 17TF.

E. V200, HV-3, Hose Valve:

1. Cast bronze globe valve, 2-1/2-inch size, with NPT screwed ends, union bonnet, rising stem, Teflon disc, hand wheel, and NPT by NST hose thread adapter outlet connection.
2. Rated 150-pound SWP, 300-pound WOG.
3. Manufacturers and Products:
    a. Nibco; Catalog No. T-235-Y, Angle No. T-335-Y.
    b. Crane Co.; Catalog No. 7TF, Angle No. 17TF.

F. YH-1, Sanitary Yard Hydrants (Freeze-proof):

1. Freestanding freeze-proof sanitary yard hydrant with automatic draining, integral ASSE 1050 double check backflow preventer, diverter spout, and drainage reservoir below frost line, 3/4-inch hose connection, 1-inch inlet connection.
2. The entire working portion of the hydrant shall be removable without excavation.
3. Bury Depth: Three feet.
4. Manufacturer and Product: Woodford Mfg. Co.; Model S4H.

2.04 PIPE HANGERS AND SUPPORTS

A. Hangers:

1. Clevis Type: MSS SP 58 and SP 69, Type 1 or 6.
    a. Anvil; Figure 104 or 260, sizes 1/2 inch through 30 inches.
    b. B-Line; Figure B3198H or B3100, sizes 3/8 inch through 30 inches.
2. Hinged Split-Ring Pipe Clamp: MSS SP 58 and SP 69, Type 6 or 12.
    a. Anvil; Figure 104, sizes 3/4 inch through 8 inches.
    b. B-Line; Figure B3198H, sizes 3/8 inch through 3 inches.
3. Hanger Rods, Clevises, Nuts, Sockets, and Turnbuckles: In accordance with MSS SP 58.
4. Attachments:
    a. I-Beam Clamp: Concentric loading type, MSS SP 58 and SP 69, Type 21, 28, 29, or 30, which engage both sides of flange.
    b. Concrete Insert: MSS SP 58 and SP 69, Type 18, continuous channel insert with load rating not less than that of hanger rod it supports.

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B. Saddle Supports:

1. Pedestal Type: Schedule 40 pipe stanchion, saddle, and anchoring flange.
   a. Nonadjustable Saddle: MSS SP 58 and SP 69, Type 37 with U-bolt.
      1) Anvil; Figure 259, sizes 4 inches through 36 inches.
      2) B-Line; Figure B3090, sizes 2-1/2 inches through 36 inches.
   b. Adjustable Saddle: MSS SP 58 and SP 69, Type 38 without clamp.
      1) Anvil; Figure 264, sizes 2-1/2 inches through 36 inches.
      2) B-Line; Figure B3093, sizes 2-1/2 inches through 36 inches.

C. Wall Brackets:

1. Welded Steel Bracket: MSS SP 58 and SP 69, Type 33 (heavy-duty).
   a. Anvil; Figure 199, 3,000-pound rating.
   b. B-Line; Figure B3067, 3,000-pound rating.
2. One-Hole Clamp: Anvil; Figure 126, sizes 3/8 inch through 4 inches.
3. Channel Type:
   a. Unistrut.
   b. Anvil; Power-Strut.
   c. B-Line; Strut System.
   d. Aickinstrut (FRP).

D. Pipe Clamps:

1. Riser Clamp: MSS SP 58 and SP 69, Type 8.
   a. Anvil; Figure 261, sizes 3/4 inch through 24 inches.
   b. B-Line; Figure B3373, sizes 1/2 inch through 30 inches.

E. Channel Type Support Systems:

1. Channel Size: 12-gauge, 1-5/8-inch-wide minimum steel, 1-1/2-inch-wide minimum FRP.
2. Members and Connections: Design for all loads with safety factor of 5.
3. Manufacturers and Products:
   a. B-Line; Strut System.
   b. Unistrut.
   c. Anvil; Power-Strut.
   d. Aickinstrut (FRP System).

F. Accessories:

1. Insulation Shields:
   a. Type: Galvanized steel or stainless steel, MSS SP 58 and SP 69, Type 40.

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b. Manufacturers and Products:
1) Anvil; Figure 167, sizes 1/2 inch through 24 inches.
2) B-Line; Figure B3151, sizes 1/2 inch through 24 inches.

2. Welding Insulation Saddles:
a. Type: MSS SP 58 and SP 69, Type 39.
b. Manufacturers and Products:
c. Anvil; Figure Series 160, sizes 1 inch through 36 inches.
d. B-Line; Figure Series B3160, sizes 1/2 inch through 24 inches.

G. Galvanize hangers, rods, clamps, protective shields, and hanger accessories.

H. Trapeze Hangers:

1. Assembly consisting of structure attachments with rod size dependent upon total weight supported, and spacing of assemblies determined by minimum pipe size included in group supported.
2. Trapeze Horizontal: Structural angle or channel section of sufficient size to prevent measurable sag between rods.
3. Manufacturers and Products:
a. Unistrut.
b. B-Line; Strut System.
c. Anvil; Power-Strut.
d. Aickinstrut (FRP System).

2.05 INSULATION

A. As specified in Section 22 07 00, Plumbing Piping Insulation.

2.06 VALVES

A. General:

1. Furnish complete with necessary operating hand wheels, chain wheels, extension stems, floor stands, worm and gear operators, operating nuts, chains, and wrenches.
2. Renewable Parts Including Discs, Packing, and Seats: Types as recommended by valve manufacturer for intended service.
3. Units shall have name of manufacturer and size of valve cast on body or bonnet or shown on a permanently attached plate in raised letters.

B. Design Features:

1. Brass and bronze components, including appurtenances in contact with water.
2. Alloys containing less than 16 percent zinc and 2 percent aluminum.

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3. Alloys are of the following ASTM designations:
    a. B61, B62, B98/B98M (Alloy A, B, or D), B139 (Alloy A), B164, B194, and B127.
    b. Stainless steel Alloy 18-8 may be substituted for bronze as an option with approval of Engineer.
4. Gland Bolts on Iron Body Valves: Bronze, fitted with brass nuts.

C. Valve Operators:

1. Open by turning counterclockwise.
2. Worm and Gear Operators On Manually Operated Valves: Totally enclosed design, proportioned as to permit operation of valve under full operating head with maximum pull of 40 pounds on handwheel or crank.
3. Self-locking type to prevent the disc or plug from creeping.
4. Self-Locking Worm Gears:
    a. One-piece design of gear bronze material, accurately machine cut.
    b. Worm: Hardened alloy steel, with thread ground and polished.
    c. Reduction gearing shall run in a proper lubricant.
5. Galvanize handwheels.

D. Gate Valves:

1. Type V100, 3 Inches and Smaller for Water and Air Services:
    a. All-bronze with screwed bonnet, single solid wedge gate with nonrising stem, and handwheel operator.
    b. Rated 125-pound SWP, 200-pound WOG.
    c. Manufacturers and Products for Threaded Ends:
        1) Crane; No. 438.
        2) Nibco; Model No. T-113.
    d. Manufacturers and Products for Soldered Ends:
        1) Crane; No. 1701S.
        2) Nibco; Model No. S-113.
2. Type V101 Gate Valve 3 Inches and Smaller:
    a. All-bronze, screwed bonnet, packed gland, single solid wedge gate, rising stem, Class 125 rated 200 psi CWP, complies with MSS SP-80 Type 2.
    b. Manufacturers and Products:
        1) Crane; Figure 428, NPT threaded ends.
        2) Stockham; Figure B-100, NPT threaded ends.
        3) Crane; Figure 1334, soldered ends.
        4) Stockham; Figure B-108, soldered ends.
3. Type V102 Gate Valve 3 Inches and Smaller:
    a. All-bronze, screwed bonnet, packed gland, NPT threaded ends, single solid wedge gate, nonrising stem, Class 150 rated 150 psi SWP/300 psi CWP, complies with MSS SP-80 Type 1.

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b. Manufacturers and Products:
    1) Crane; Figure 437.
    2) Stockham; Figure B-128.

4. Type V103 Gate Valve 3 Inches and Smaller:
    a. All-bronze, screwed bonnet, packed gland, NPT threaded ends, single solid wedge gate, rising stem, Class 150 rated 150 psi SWP/300 psi CWP, complies with MSS SP-80 Type 2.
    b. Manufacturers and Products:
        1) Crane; Figure 431.
        2) Stockham; Figure B122.
5. Type V108, 4 Inches and Larger for Water and Air Services:
    a. Iron body, bronze mounted, with flanged ends, solid wedge gate with nonrising stem, and handwheel operator.
    b. Rated 125-pound SWP, 200-pound WOG.
    c. Manufacturers and Products:
        1) Crane; No. 461.
        2) Nibco; Model No. F-619.
6. Type V137 Resilient Seated Gate Valve 4 Inches to 12 Inches:
    a. UL listed and FM approved for fire protection, iron body, resilient seat, bronze mounted, ASME B16.1 Class 125 flanged ends, nonrising stem, 2-inch operating nut, in accordance with AWWA C509, design working water pressure 200 psig, full port, fusion-epoxy coated inside and outside per AWWA C550, NSF/ANSI 61 certified.
    b. Manufacturers and Products:
        1) Kennedy Valve; Ken-Seal II.
        2) M&H Valve; Style 4067.
        3) Mueller; P-2360.
7. Type V140 Gate Valve 3/4 Inch to 2 Inches:
    a. UL listed and FM approved, all bronze, solid wedge disc, outside screw and yoke, screwed ends rated 175-pound WOG minimum.
    b. Supervisory switch. Valve supervised in OPEN position so closing results in actuation of alarm.
    c. Manufacturer and Product: Kennedy; UL/FM.

E. Globe Valves:

1. Type V200 Globe Valve 3 Inches and Smaller:
    a. All-bronze, union bonnet, packed gland, inside screw, rising stem, TFE disc, Class 150 rated 150 psi SWP/300 psi CWP, complies with MSS SP-80 Type 2.
    b. Manufacturers and Products:
        1) Stockham; Figure B-22T, NPT threaded end.
        2) Crane Co.; Figure 7TF, NPT threaded end.
        3) Milwaukee; Model 1590T, soldered ends.
        4) NIBCO; Figure S-235-Y, soldered ends.

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2. Type V201 Angle Pattern Valve 2 Inches and Smaller:
    a. All-bronze, NPT threaded ends, union bonnet, packed gland, inside screw, rising stem, TFE disc, Class 150 rated 150 psi SWP/300 psi CWP, complies with MSS SP-80 Type 2.
    b. Manufacturers and Products:
        1) Stockham; Figure B-222T.
        2) Crane Co.; Figure 17TF.
3. Type V235 Angle Type Hose Valve 3/4 Inch:
    a. 3/4-inch NPT female inlet, 3/4-inch male hose thread outlet, heavy rough brass body rated 125 psi, lockshield bonnet, removable handle, atmospheric vacuum breaker conforming to ASSE 1011 and IAPMO code.
    b. Manufacturers and Products:
        1) Acorn; 8126, surface pipe mount valve, bent nose without flange.
        2) Acorn; 8121, surface mount through wall valve, bent nose with flange.
        3) Acorn; 8131, pipe and pedestal mounted valve located above 6 inches, straightnose.
        4) Acorn; 8136, pedestal mounted valve located lower than 6 inches, inverted nose.
4. Type V236 Globe Style Hose Valve 1 Inch to 3 Inches:
    a. All-bronze, NPT threaded ends, inside screw-type rising stem, TFE disc, cast brass male NPT by male NHT adapter with hexagonal center wrench nut, complies with MSS SP-80, rated 300 WOG.
    b. Manufacturers and Products:
        1) Stockham; Figure B-22T.
        2) Crane Co.; Cat. No. 7TF.
        3) Nibco; Figure T-235-Y.
5. Type V237 Angle Pattern Hose Valve 1 Inch to 2 Inches:
    a. All-bronze, NPT threaded ends, inside screw-type rising stem, TFE disc, cast brass male NPT by male NHT adapter with hexagonal center wrench nut, complies with MSS SP-80, rated 300 WOG.
    b. Manufacturers and Products:
        1) Stockham; Figure B-222T.
        2) Crane Co.; Cat. No. 17TF.
        3) Nibco; Figure T-335-Y.

F. Ball Valves:

1. 2 Inches and Smaller for General Water and Air Service:
    a. Three-piece body type, bronze body and end pieces, hard-chrome plated bronze or brass ball, full bore port, RTFE seats and

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packing, blowout-proof stem, zinc-plated steel hand lever operator with vinyl grip.

b. Rated 6-pound WOG, 150-psi SWP.

c. Manufacturers and Products:

1) Threaded Ends:

a) Milwaukee; BA-300.

b) Nibco; T-595-Y.

c) Conbraco Apollo; 82-100.

2) Soldered Ends:

a) Milwaukee; BA-350.

b) Nibco; S-595-Y.

c) Conbraco Apollo; 82-200.

2. 3 Inches and Smaller for Vacuum Service:

a. Brass body and trim, replaceable double TFE seals and seats.

b. Furnish screwed ends and rate for service to 0.01 micron.

c. Manufacturers and Products:

1) Jamesbury; Style A.

2) Worcester; Series 400.

3. Thermoplastic Ball Valves 2 Inches and Smaller for Water Service:

a. Rated 150 psi at 105 degrees F, with ASTM D1784, Type I, Grade 1 polyvinyl chloride (PVC) body, ball, and stem.

b. End entry, double union design, with replaceable Teflon seats and Viton or Teflon O-ring stem seals.

c. Furnish with hand lever operator.

d. Single union ball valves with flanged ends drilled to 150-pound ANSI Standard are acceptable.

e. Manufacturers:

1) Asahi/America.

2) R&G Sloane Manufacturing Co., Inc.

4. Deionized Water Ball Valve (1/2 Inch to 2 Inches):

a. True union ball valve, size as shown on Drawings.

b. Manufactured from virgin polypropylene using no antioxidants, plasticizers, or pigments.

c. Socket-weld type electrically fused. Factory sealed in a protective wrap.

d. Minimum pressure rated of 140 psi at 70 degrees F.

e. Manufacturers:

1) R&G Sloane Manufacturing Co., Inc.

2) Orion Fittings, Inc.

3) Chemline Plastics Ltd.

G. Globe Valves:

1. 3 Inches and Smaller:

a. Bronze body, replaceable composition disc, screwed ends, union bonnet, inside screw rising stem, and TFE disc.

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b. Rated 150-pound SWP, 300-pound WOG.
c. Manufacturers and Products:
1) Crane; No. 7TF.
2) Nibco; No. T-235-Y.

H. Angle Valves 3 Inches and Smaller:

1. Bronze body, threaded ends, union bonnet, and rising stem.
2. Rated 150-pound SWP and 300-pound WOG.
3. Manufacturers and Products for Threaded End:
a. Crane; No. 17TF.
b. Nibco; No. T-335-Y.

I. Check Valves 3 Inches and Smaller:

1. Bronze body, wye pattern, threaded ends and cap, regrinding seat, and swing type disc.
2. Rated 125-pound SWP, 200-pound WOG.
3. Manufacturers and Products:
a. Crane; No. 37.
b. Walworth Co.; Figure 406.

J. Backwater Check Valve 2 Inches to 8 Inches:

1. Coated cast iron backwater check valve, integral offset type swing-check assembly, gasketed bolted access cover.
2. Manufacturers and Products:
a. J. R. Smith; Figure 7012.
b. Josam; Series 67500.
c. Zurn; Model Z-1095.

K. Balancing Valves (Recirculating Hot Water):

1. Bronze, calibrated balancing type with provisions for connecting a portable differential pressure meter. Meter connections shall have built-in check valves.
2. An integral pointer shall register degree of valve opening.
3. Construct with internal seals to prevent leakage around rotating element.
4. Rated for 125 psig working pressure at maximum temperature of 250 degrees F.
5. Furnish one pressure gauge type readout meter in carrying case.
6. Furnish with preformed polyurethane insulation valve enclosure, suitable for use on hot water systems.
7. Manufacturers and Products:
a. Bell & Gossett; No. CB circuit setter.
b. TACO; Series 790.

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L. Water Pressure Reducing Valves 1/2 Inch Through 2-1/2 Inches:

1. Spring controlled, with a neoprene diaphragm.
2. Sizes and Ratings:
    a. PRV-1: Outlet pressure 80 psig.
3. Manufacturers and Products:
    a. Fisher; Type 75.
    b. Watts; No. 223.

M. Gauge Cock Valves 1/8 Inch to 3/8 Inch:

1. Bronze body, hexagon male and female ends, and tee head.
2. Rated for 125-pound SWP.
3. Manufacturers and Product:
    a. Ernst Gage Co.
    b. Lunkenheimer.

N. Manual Air Vent Valves:

1. With coin-operated air vent.
2. Manufacturers and Products:
    a. Bell & Gossett; No. 4V.
    b. Dole; No. 9.

O. Point of Use Thermostatic Mixing Valve Assembly (3/8-inch Under Sink):

1. Function: Provide tempered water at 0.5 gpm to 2.25 gpm.
2. Listed per ASSE 1070. Bronze body, lead free construction rated to 150 psig maximum inlet pressure.
3. Inlets: One each, 3/8-inch compression fittings, cold and hot water.
4. Outlet: 3/8-inch compression fittings.
5. Self-contained; no electrical requirements.
6. Performance: With 120 degrees F to 180 degrees F hot inlet and 39 degrees F to 85 degrees F cold inlet, deliver 80 degrees F to 100 degrees F at inlet pressures between 30 psig and 100 psig.
7. Set outlet at 105 degrees F maximum unless otherwise noted.
8. Manufacturers and Products:
    a. Watts; LFUSG-B-M2.
    b. Powers; LFe480.
    c. Leonard Valve; Model 170-LF.

P. Point of Use Emergency Thermostatic Mixing Valve Assembly (1/2 Inch):

1. Function: Provide tempered water at 2 gpm to 10 gpm.
2. Listed per ASSE 1071. Bronze body, lead free construction rated to 125 psig maximum inlet pressure.
3. Integral thermometer with local indication.

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4. Inlets and Outlet: 1/2-inch NPT.
5. Angle check-stop valves on inlets.
6. Compliance with ANSI Z358.1.
7. Self-contained; no electrical requirements.
8. Performance: With 120 degrees F to 180 degrees F hot inlet and 39 degrees F to 85 degrees F cold inlet, deliver 80 degrees F to 100 degrees F at inlet pressures between 30 psig and 100 psig.
9. Set outlet at 85 degrees F.
10. Manufacturers and Products:
    a. Leonard Valve Co.; TA-300-LF.
    b. Haws; Model 9201EW.

Q. Thermostatic Mixing Valve Assembly:

1. Function: Provide tempered water at 3 gpm to 50 gpm.
2. Components:
    a. High flow mixing valve for 15 gpm to 50 gpm.
    b. Low flow mixing valve for 3 gpm to 7 gpm.
    c. Pressure reducing valve.
    d. Pressure gauge.
    e. Isolation valve.
    f. Thermometer.
    g. Pipe fittings.
    h. Heavy-gauge steel cabinet with access door and manufacturer's standard baked enamel finish.
3. Inlets: One each, 3/4-inch NPT, cold and hot water.
4. Outlets: 1 inch NPT.
5. Self-contained; no electrical requirements.
6. Performance: With 140 degrees F hot inlet and 60 degrees F cold inlet, deliver 100 degrees F at inlet pressures between 30 psig and 100 psig. Set outlet at 95 degrees F.
7. Manufacturers and Products:
    a. Powers Process Controls; Series 430/420 Hydroguard.
    b. Leonard; Model TM 850.
    c. Powers ETV400 for multiple emergency showers.

2.07 MISCELLANEOUS PIPING SPECIALTIES

A. Strainers for Water Service:

1. Iron body, Y-pattern, 125-pound rated, with screwed bronze or bolted iron cap.
2. Screen: Heavy-gauge stainless steel or monel, 30 mesh.
3. Manufacturers and Products:
    a. Crane; No. 988-1/2.
    b. Mueller; No. 758.

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B. Vacuum Breakers 2 Inches and Smaller:

1. Angle type, as required.
2. Manufacturers:
    a. Febco.
    b. Watts.

C. Water Hammer Arresters:

1. Materials: ASSE 1010 certified, Type L copper tube, HHPP piston with two lubricated EPDM O-rings, FDA approved lubricant, rolled piston stop, wrought copper male thread adapter.
2. Manufacturers and Products:
    a. Sioux Chief Mfg. Co., Inc.; Series 650 and 660.
    b. Precision Plumbing Products, Inc.

D. Water Hose:

1. Furnish two 50-foot length(s) of 1-1/2-inch, EPDM black cover and EPDM tube, reinforced with two textile braids. Furnish each length with brass male and female NST hose thread couplings to fit hose nozzle(s) and hose valve(s) specified.
2. Rated minimum working pressure of 200 psi.
3. Manufacturers:
    a. Goodyear.
    b. Boston.

E. Hose Nozzles:

1. Furnish two 1-1/2-inch cast brass satin finish nozzle(s) with adjustable fog, straight-stream, and shutoff features and rubber bumper. Provide nozzle(s) with female NST hose thread.
2. Manufacturers:
    a. Croker.
    b. Elkhart.

F. Sleeves:

1. Manufacturers and Products:
    a. J. R. Smith; Figure 1720.
    b. Josam; No. 26400.

G. Flashing Sleeves for Roof Penetrations:

1. Built-Up Bituminous Roofing: Fabricate of lead as specified in Section 07 62 00, Sheet Metal Flashing and Trim.

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2. Single-Ply Membrane Roofing: Pipe seals as specified in Section 07 70 01, Roof Specialties and Accessories.

H. Insulating Dielectric Unions and Flanges:

1. Galvanically compatible with piping to which attached and pressure ratings suitable for system working pressures.
2. Unions 2 Inches and Smaller: Screwed or solder-joint type.
3. Unions 2-1/2 Inches and Larger: Flanged type, complete with bolt insulators, dielectric gasket, bolts, and nuts.
4. Manufacturers:
   a. Epco Sales, Inc., Cleveland, OH.
   b. Capitol Insulation Unions.

I. Joint Solder: 95-5 wire solder, ASTM B32, Grade 95 TA. Lead free, NSF certified. Do not use cored solder.

J. Pipe Joint Sealer: Compound insoluble in water or Teflon tape; approved by NFS for use in potable water.

K. Rubber Gaskets: ASTM C564.

2.08 MEASURING DEVICES

A. Thermometers:

1. Adjustable angle, organic spirit type, blue in color, with 9-inch case and scale range in degrees F, as shown.
2. Furnish with 3-1/2-inch stem length and separable NPT brass thermowell.
3. Manufacturers and Product:
   a. Trerice Co.; Model A005.
   b. Weksler.

B. Pressure Gauges:

1. Construction: 3-1/2-inch gauge size, 0 kPa to 690 kPa, 0 psi to 160 psi range, steel case, glass crystal, brass movement, and 1/4-inch NPT lower connection.
2. Furnish with 1/4-inch brass gauge cock.
3. Manufacturers and Products:
   a. Ashcroft; Type 1008.
   b. Marsh; J80.
   c. Marshalltown.

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PART 3 EXECUTION

3.01 GENERAL

A. Install plumbing systems to meet applicable plumbing code.

B. Field Obstructions:

1. Drawings do not attempt to show exact details of piping. Provide offsets around obstructions.
2. Do not modify structural components, unless approved by Engineer.

C. Sleeves:

1. Pipe sizes shown are nominal sizes, unless shown or specified otherwise.
2. Provide piping passing through walls, floors, or ceilings with standard-weight pipe sleeves.
3. Provide pipes passing through finished walls with chrome-plated canopy flanges.
4. Dry pack sleeves in existing work in-place and provide finished appearance.
5. Pack holes left by removal of existing piping with grout and finish to match adjacent surface.

D. Provide unions in piping systems at connections to equipment.

E. Provide shielded transition couplings, insulating dielectric unions and flanges between ferrous and nonferrous piping and where otherwise required for electrically insulated connection.

F. Pipe air release valves, water-lubricated bearings, and other appurtenances having water effluent with copper tubing to nearest drain.

G. Provide isolation valves and strainers at pressure regulators.

H. Trench Excavation and Backfill: As specified in Section 31 23 16, Excavation, and Section 31 23 23.15, Trench Backfill.

3.02 INSTALLATION

A. Steel Pipe:

1. Ream, clean, and remove burrs and mill scale from piping before making up.
2. Seal joints with pipe joint sealer or Teflon tape.

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B. Copper Tubing:

1. Cut tubing square and remove burrs.
2. Clean both inside of fittings and outside of tubing with steel wool and hydrochloric acid before soldering.
3. Prevent annealing of fittings and hard-drawn tubing when making connections.
4. Do not use mitered joints for elbows or notching of straight runs of pipe for tees.

C. Rigid PVC or CPVC:

1. Cut, make up, and install in accordance with pipe manufacturer's recommendations.
2. Ream, clean, and remove burrs from cut ends before joining pipe.
3. Lay in trench by snaking pipe from one side to other.
4. Offset: As recommended by manufacturer for maximum temperature variation between time of solvent welding and final use.
5. Do not lay pipe when temperature is below 40 degrees F or above 90 degrees F when exposed to direct sunlight.
6. Shield ends to be joined from direct sunlight prior to and during laying operation.
7. Use strap wrenches only for tightening threaded plastic joints. Do not over tighten fittings.

D. Water System Balancing: Provide a qualified registered engineer or firm specializing in testing and balancing to adjust domestic water system. Balance system for required water flows at each plumbing fixture, terminal device, and recirculating hot water loop.

E. Water Hammer Arresters:

1. Install in piping systems where shown on Drawings and adjacent to pieces of equipment where quick closing valves are installed.
2. Install at all emergency safety showers and eyewashes.
3. Size and install in accordance with PDI-WH201.
4. Shock arresters to have access panels or to be otherwise accessible.

F. Valves: Install in accordance with manufacturer's recommendations.

G. Miscellaneous Piping Specialties: Install in accordance with manufacturer's recommendations.

H. Measuring Devices: Install in accordance with manufacturer's recommendations.

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3.03 SANITARY AND WASTE DRAINS AND VENTS PIPING

A. Installation:

1. Set piping above floor slab true and plumb.
2. Set exposed risers as close to walls as possible.
3. Slope drain lines at minimum 2 percent slope, unless otherwise noted. Vent lines shall be installed level or sloped, with no low spots.
4. Where vent stacks pass through roof slab, fit with flashing sleeve secured to roof.
5. Extend vents minimum 1 foot above roof.
6. Provide cleanouts where shown and where required by code.

3.04 ACID-RESISTANT DRAINS AND VENTS

A. Install in accordance with manufacturer's recommendations.

B. Drainage Vents: Same piping system as used for acid-resistant drains.

C. Make connections between polypropylene piping systems and other acid-resistant drainage systems with adapters recommended by manufacturer.

D. Buried Polypropylene Pipe:

1. Heat join and test for leakage before placing in trench.
2. Snake slightly on long runs placed in trench.
3. When installed in extremely hot or cold weather, make proper allowance for expansion or contraction.

E. Buried Acid-Resistant Cast Iron Pipe With Teflon-Lined Couplings:

1. Install in accordance with manufacturer's instructions.
2. Do not allow acid waste to contact pipe and Teflon until installation is complete and tested.

F. Buried Polypropylene Drain and Vent Pipe:

1. Install in accordance with manufacturer's recommendations.
2. Trench shall have a clean sand bed graded to proper pitch.
3. Completely cover pipe with clean sand prior to backfilling.
4. Compact sand by flooding with water.
5. Do not permit sharp stones in backfill surrounding pipe.

3.05 HVAC CONDENSATE PIPING

A. Set piping true and plumb.

B. Slope piping 1/8 inch per foot minimum.

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3.06 WATER SUPPLY PIPING

A. Water supply piping includes potable CW (W1), hot water (HW), return hot water (HWR), tempered water systems and nonpotable NP (W2) systems, and tepid water systems.

B. Flush water piping systems clean of internal debris, clean faucet aerators, and adjust plumbing fixture valves for manufacturer's recommended flow.

C. Do not run water piping through electrical rooms, stairwells, or immediately over or within a 3-foot horizontal clearance of electrical panels, motor starters, or environmental control panels.

D. Provide exterior water piping with minimum 3 feet of cover or install below frost line, whichever is greater.

E. Hose Valves and Hydrants: Attach handle with setscrew and provide manufacturer's recommended gravel fill around drain hole of post hydrants.

F. Provide valve operators with position indicators, where indicated, to show position of valve disc or plug.

G. Provide bypass with globe valve for emergency throttling around each reducing valve.

H. Protect buried copper and steel pipe and fittings with a single wrap of coal-tar saturated felt in accordance with AWWA C203.

I. Vacuum Breakers 2 Inches and Smaller: Install minimum 6 inches above flood line of equipment they serve.

J. Provide manual air vents at high points in domestic hot water system.

3.07 INSULATION

A. As specified in Section 22 07 00, Plumbing Piping Insulation.

3.08 HANGERS AND SUPPORTS

A. Install pre-engineered support equipment in accordance with manufacturer's recommendations.

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B. Hanger Rod Sizing and Spacing for:

1. Steel Pipe:

Pipe Size	Max. Hanger Spacing (feet)	Min. Rod Size (inches)
1 inch and smaller	6	1/4
1-1/4 through 2-1/2 inches	8	1/4
3 and 4 inches	10	3/8
6 inches	12	3/8
8 inches	12	1/2

2. Copper Pipe:
   a. Rod Size: Same as for steel pipe.
   b. Spacing: 2 feet less per size than for steel pipe, except pipe 1-1/4 inches and smaller shall be supported every 6 feet.
3. Cast Iron Pipe:
   a. Rod Size: Same as for steel pipe.
   b. Spacing: Locate hanger rods at each pipe joint and change of direction, 10-foot maximum spacing.
4. Plastic Pipe:
   a. Rod Size: Same as for steel pipe.
   b. Spacing: As recommended by manufacturer and required by applicable plumbing code for flow and temperature in pipe.
   c. No metal portion of hanger shall contact pipe directly.

C. Attach Support Rods For Horizontal Piping:

1. To steel beams with I-clamps.
2. To concrete with inserts or with flanges fastened with flush shells.
3. To wood with thickness of 2-1/2 inches or more with bolts or angle clips.

D. Trapeze Hangers:

1. Trapeze hangers may be used in lieu of individual hangers where horizontal piping is arranged with two or more parallel lines.
2. Attach lines to horizontal with U-bolts or one-hole clamps.

E. Vertical Piping:

1. Support by channel type support system and pipe clamps on 10-foot maximum centers.

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2. Copper and Plastic Piping: Isolate from channels and pipe clamps with pipe isolators.

F. Insulated Piping: Furnish galvanized protection shield and oversized hangers under insulated piping.

3.09 INTERIM CLEANING

A. Prevent accumulation of weld rod, weld spatter, pipe cuttings and filings, gravel, cleaning rags, and other foreign material within piping during fabrication and assembly.

B. Examine piping to assure removal of foreign objects prior to assembly.

C. Conventional commercial cleaning methods of cleaning are acceptable if method and cleaning material does not corrode, deform, swell, or otherwise alter physical properties of material being cleaned.

3.10 TESTING

A. General:

1. Conduct pressure and leakage tests on newly installed pipelines.
2. Provide necessary equipment and material, and make taps in pipe, as required.
3. Owner will monitor tests. Provide 24-hour advance notice of start of testing.
4. Test Pressures: As specified herein and in Piping Schedule.
5. Test Records: Make records of each piping system installation during test to document the following:
    a. Date of test.
    b. Description and identification of piping tested.
    c. Test fluid.
    d. Test pressure.
    e. Remarks, including:
        1) Leaks (type, location).
        2) Repairs made on leaks.
    f. Certification by Contractor and signed acknowledgment by Owner that tests have been satisfactorily completed.

B. Testing New Pipe Connected to Existing Pipe: Isolate new pipe with grooved end pipe caps, spectacle blinds, or blind flanges.

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C. Preparation and Execution:

1. Buried Pressure Piping:
   a. An initial service leak test may be conducted with a partially backfilled trench and the joints left open for inspection, if field conditions permit, as determined by Engineer.
   b. Expose joints for the acceptance test on buried pressure piping to be pneumatically tested or subjected to an initial service leak test.
   c. Conduct final hydrostatic acceptance tests after trench has been completely backfilled.
2. Exposed Piping: Conduct tests after piping has been completely installed including supports, hangers, and anchors, but prior to insulation.

D. Hydrostatic Leak Tests:

1. Equipment: Provide the following:

Amount	Description
2	Graduated containers
2	Pressure gauges
1	Hydraulic force pump
	Suitable hose and suction pipe as required

2. Procedure:
   a. Use water as the hydrostatic test fluid.
   b. Provide clean test water of such quality as to minimize corrosion of the materials in the piping system.
   c. Open vents at high points of the piping system to purge air pockets while the piping system is filling.
   d. Venting during filling of system may also be provided by loosening flanges with a minimum of four bolts or by the use of equipment vents.
   e. Test piping systems at test pressure specified in Piping Schedule.
   f. Maintain hydrostatic test pressure continuously for 30 minutes minimum and for such additional time as necessary to conduct examinations for leakage.
   g. Examine joints and connections for leakage.
   h. Piping system, exclusive of possible localized instances at pump or valve packing, shall show no visual evidence of weeping or leaking.
   i. Correct visible leakage and retest to satisfaction of Owner.

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3. Buried Water Lines:
   a. A limited amount of leakage is permissible according to formula specified.
   b. Conduct hydrostatic testing as follows:
      1) Pipe with Concrete Thrust Blocking: Do not make pressure test until a minimum of 5 days after thrust blocking is installed.
      2) If high-early strength cement is used for thrust blocking, time may be reduced to 2 days.
   c. Cement-Lined Piping: Slowly fill test section with water and allow to stand for 24 hours under slight pressure to allow cement lining to absorb water.
   d. Expel air from piping system prior to testing.
   e. Apply and maintain specified test pressure with hydraulic force pump.
   f. Valve off the piping system when test pressure is reached.
   g. Conduct pressure test for 2 hours, reopening isolation valve only as necessary to restore test pressure.
   h. Accurately measure amount of water required to maintain test pressure by placing pump suction in a barrel or similar device, or by metering.
   i. The measurement represents leakage, defined as the quantity of water necessary to maintain the specified test pressure for the duration of the test period.
   j. Determine maximum allowable leakage in gallons per hour from the following formula:

$$L = \frac{ND(P)^{1/2}}{7400}$$

      where:

      L = Allowable leakage, in gallons per hour
      N = Number of joints in the length of pipe tested
      D = Nominal diameter of pipe, in inches
      P = Test pressure during the leakage test, in pounds per square inch

   k. Correct leakage greater than the allowable determined under this formula, and retest to satisfaction of Owner.
4. Test Pressure for Water: 1-1/2 times system pressure.
5. Gravity Sewers and Drains:
   a. Test by water or air exfiltration tests as prescribed by local or state plumbing codes and visually examine for leaks.
   b. Repair leaks and retest system until no further leakage is evident.

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3.11 CLEANING AND DISINFECTION

A. Prior to final acceptance, following assembly and testing, flush pipelines with water, except for plant process air lines and instrument air lines, and remove accumulated construction debris and other foreign matter.

B. Minimum Flushing Velocity: 2.5 feet per second.

C. Insert cone strainers in the connections to attached equipment and leave until cleaning has been accomplished.

D. Remove accumulated debris through drains 2 inches and larger or by dropping spools and valves.

E. Immediately after draining flushed lines, dry piping with compressed air.

F. Use compressed air to remove loose debris from plant process air and instrument air piping.

G. Disinfect potable water pipelines before placing in service:

1. Meet the requirements of AWWA C651, unless otherwise specified.
2. Disinfecting Mixture:
    a. A chlorine-water solution having a free chlorine residual of 40 ppm to 50 ppm.
    b. Prepare by injecting one of the following:
        1) Liquid chlorine gas-water mixture.
        2) Dry chlorine gas.
        3) Calcium or sodium hypochlorite and water mixture.
    c. Inject mixture into pipeline at a measured rate while freshwater is allowed to flow through the pipeline at a measured rate so the combined mixture of freshwater and chlorine solution or gas is of the specified strength.
    d. Apply liquid chlorine gas-water mixture by means of a chlorinating device.
    e. Feed dry chlorine gas through proper devices for regulating the rate of flow and providing effective diffusion of gas into water within pipe being treated.
    f. Chlorinating devices for feeding solutions of chlorine gas or gas itself must prevent backflow of water into chlorine cylinder.
    g. Calcium Hypochlorite: If this procedure is used, first mix dry powder with water to make a thick paste, then thin to approximately a 1 percent solution (10,000 ppm chlorine).
    h. Sodium Hypochlorite: If this procedure is used, dilute liquid with water to obtain a 1 percent solution.

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i. The following proportions of hypochlorite to water will be required:

Product	Quantity	Water
Calcium Hypochlorite1 (65 - 70 percent C1)	1 lb	7.5 gal
Sodium Hypochlorite2 (5.25 percent C1)	1 gal	4.25 gal
1 Comparable to commercial products known as HTH, Perchloron, and Pittchlor. 2 Known as liquid laundry bleach, Clorox, and Purex.		

H. Point of Application:

1. Inject chlorine mixture into pipeline to be treated at the beginning of the line through a corporation stop or suitable tap in the top of pipeline.
2. Control clean water from existing system or another source so it flows slowly into newly installed piping during chlorine application.
3. Manipulate valves so the strong chlorine solution in the line being treated will not flow back into line supplying the water. Use check valves, if necessary.

I. Retention Period:

1. Retain treated water in pipeline for a minimum of 24 hours or long enough to destroy nonspore-forming bacteria.
2. At the end of the retention period, the disinfecting mixture shall have strength of at least 10 ppm of chlorine.
3. Operate valves, hydrants, and other appurtenances during disinfection to assure disinfecting mixture is dispersed into all parts of the pipeline including dead ends, new services, and similar areas that otherwise may not receive the disinfecting solution.
4. Do not place concentrated quantities of commercial disinfectants in pipeline before filling with water.
5. After chlorination, flush water from permanent source of supply until water through pipeline is equal chemically and bacteriologically to permanent source of supply.

J. Disposal of Disinfecting Water:

1. Dispose of disinfecting water in accordance with permits and regulations. Protect the public and receiving waters from harmful or toxic concentrations of chlorine.

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2. Do not allow disinfecting water to flow into a waterway without adequate dilution or other satisfactory method of reducing chlorine concentrations to a safe level.

3.12 PROTECTION OF INSTALLED WORK

A. Protective Covers:

1. Provide over floor and shower drains during construction, to prevent damage to drain strainers and keep foreign material from entering drainage system.
2. Cover roof drains and emergency overflow drains during roofing process so roofing material and gravel do not enter drain piping.
3. Remove at time of Substantial Completion.

3.13 PIPING IDENTIFICATION

A. Refer to Section 40 27 00, Process Piping—General, and Pipe Schedule.

3.14 SUPPLEMENTS

A. The supplements listed below, following "End of Section," are part of this specification.

1. 22 10 01.01, Plumbing Piping Schedule.
2. Plumbing Piping Data Sheets.

Section Number	Title
22 10 01.02	Polyvinyl Chloride Drain Waste and Vent (PVC-DWV) Pipe and Fittings
22 10 01.03	Cast Iron Soil Pipe (CISP) and Fittings
22 10 01.04	Acid-Resistant Cast Iron Pipe and Fittings
22 10 01.05	Acid-Resistant Glass Pipe and Fittings
22 10 01.06	Acid-Resistant Polypropylene Waste and Vent Pipe and Fittings
22 10 01.07	Perforated Polyvinyl Chloride (PVC) Pipe and Fittings
22 10 01.08	High-Density Polyethylene (HDPE) Pipe and Fittings—Water and Sewer Service
22 10 01.09	High Purity Polypropylene (HP-PP) Pipe and Fittings
22 10 01.10	Carbon Steel Tubing and Fittings (High Pressure)

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Section Number	Title
22 10 01.11	Galvanized Steel Drain and Vent Pipe and Fittings

END OF SECTION

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SECTION 22 10 01.01
PLUMBING PIPING SCHEDULE

Legend	Service	Size(s) (in.)	Exposure	Piping Material	Specification Section	Operating Pressure (psig)	Test Type	Test Pressure (psig)	Pipe Colors and Labels	Notes
ARD, ARV	Acid Resistant Drain	All	EXP/BUR	PP	22 10 01.06		H			
CD	Condensate Drain, HVAC	All	EXP/BUR	COP	40 27 00.13	NA	H	5		
CD	Condensate Drain, HVAC	All	EXP/BUR	PVC-DWV	22 10 01.02	NA	H	5		
D	Sanitary Drain	All	EXP/BUR	PVC-DWV	22 10 01.02	NA	H	5		
D	Sanitary Drain	All	EXP/BUR	CISP	22 10 01.03	NA	H	5		
HW, HWR	Hot Water, Potable	All	EXP/BUR	COP	40 27 00.13		H			
PD	Sump Pump Discharge	3 - 6	EXP/BUR	CLDI	40 27 00.01		H			
TP	Trap Primer	1/2 - 3/4	EXP/BUR	COP	40 27 00.13	NA	H			
TW	Tempered Water, Potable	All	EXP/BUR	COP	40 27 00.13		H			
V, VTR	Sanitary Vent	All	EXP	PVC-DWV	22 10 01.02	NA	H	5		
V, VTR	Sanitary Vent	All	EXP	CISP	22 10 01.03	NA	H	5		
CW, W1	Cold Water, Potable	All	EXP/BUR	COP PVC	40 27 00.13 40 27 00.10		H			Copper Inside Building, PVC Outside Building

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SECTION 22 10 01.01
PLUMBING PIPING SCHEDULE

Legend	Service	Size(s) (in.)	Exposure	Piping Material	Specification Section	Operating Pressure (psig)	Test Type	Test Pressure (psig)	Pipe Colors and Labels	Notes
NP, W2	Cold Water, Non-Potable	All	EXP/BUR	CPVC PVC	40 27 00.11 40 27 00.10		H			CPVC Inside Building, PVC Outside Building

Notes:

1. Refer to Section 23 23 00, Refrigerant Piping, for testing requirements.
2. Finish all FS piping exposed to view, color to be OSHA red, in accordance with Section 09 90 00, Painting and Coating, Paint System No. 5.
3. Heat trace as specified in Section 40 05 33, Pipe Heat Tracing.
4. Insulate as specified in Section 22 07 00 Building Mechanical Thermal Insulation.

Legend

Exposure		Pressure Test		Material	
BUR	Buried	H	Hydrostatic	ACR	Air-Conditioning and Refrigeration
EXP	Exposed	I	In Service	CISP	Cast Iron Soil Pipe
SUB	Submerged	P	Pneumatic	CLDI	Cement-Lined Ductile Iron
ENC	Concrete Encased	NA	Not Applicable	CMP	Corrugated Metal Pipe
				COP	Copper
				CPVC	Chlorinated PVC
				DI	Ductile Iron
				DWV	Drain Waste and Vent
				FRPX	Fiberglass Reinforced Plastic
				GLDI	Glass-Lined Ductile Iron

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Legend		
Exposure	**Pressure Test**	**Material**
		GSP Galvanized Steel Pipe
		HDPE High Density Polyethylene
		MDPE Medium Density Polyethylene
		PP Polypropylene Pipe
		PSTL PVDF-Lined Steel
		PVC Polyvinyl Chloride
		PVDF Polyvinylidene Fluoride
		RCP Reinforced Concrete Pipe
		RSTL Rubber-Lined Steel
		SST Stainless Steel
		STL Steel
		VC Vitrified Clay Pipe

END OF SECTION

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SECTION 22 10 01.02
POLYVINYL CHLORIDE
DRAIN WASTE AND VENT (PVC-DWV)
PIPE AND FITTINGS

Item	Size	Description
Pipe and Fittings	All	PVC-DWV Schedule 40 nonpressure application, Class 12454B conforming to ASTM D2665 and ANSI/NSF Standard 14 system.
Joints	All	Solvent cemented conforming to ASTM D2855 except where connection to equipment may require future removal.
Solvent Cement	All	As recommended by the pipe and fitting manufacturer conforming to ASTM D2564.

END OF SECTION

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SECTION 22 10 01.03 CAST IRON SOIL PIPE (CISP) AND FITTINGS		
Item	**Size**	**Description**
Pipe	6" and smaller	Hubless, CISPI 301, service weight, no-hub ends.
	8" and larger	Hub and spigot, ASTM A74, service weight, single hub and spigot.
Joints	6" and smaller	Coupling: Conform to ASTM C564, ASTM C1277, and CISPI 310. Compression: Neoprene sealing sleeve with 24-gauge Type 304 stainless steel shield and clamp assembly. Joints to dissimilar material shall comply with ASTM C1460.
	8" and larger	Rubber gaskets, ASTM C564.
Fittings	6" and smaller	Conform to ASTM A888 and CISPI 301
	8" and larger	Conform to ASTM A74
Coating	All	Bituminous-coated inside and out; marked with manufacturer's name or trademark and CISPI symbol.

END OF SECTION

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SECTION 22 10 01.04
ACID-RESISTANT CAST IRON PIPE AND FITTINGS

Item	Size	Description
Pipe and Fittings	All	High silicone cast iron, no-hub ends, extra heavy grade, conforming to ASTM A518/A518M and ASTM A861.
Joints	All	No-hub type compression coupling, with Teflon inner sleeve, neoprene outer sleeve, and stainless steel shield and clamp assembly.

END OF SECTION

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SECTION 22 10 01.06
ACID-RESISTANT POLYPROPYLENE WASTE AND VENT PIPE AND FITTINGS

Item	Size	Description
Pipe	All	Polypropylene, ASTM F1412, Type 1, Schedule 40; resin meeting ASTM D4101. Conforming to ASTM D2447, ASTM D635, and ASTM D2843.
Fittings	All	Polypropylene, ASTM F1412, Type 1, Schedule 40, socket type ends conforming to ANSI B16.12, ASTM D2657, and ASTM D4101.
Joints	All	Socket-weld type, electrically fused.
Manufacturers		R & G Sloane Manufacturing Co., Inc. Celanese Piping Systems, Inc. Orion Fittings, Inc.

END OF SECTION

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SECTION 22 30 00
PLUMBING EQUIPMENT

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Society of Heating, Refrigerating & Air-Conditioning Engineers, Inc. (ASHRAE): 90.1, Energy Standard for Buildings Except Low-Rise Residential Buildings.
2. American Society of Mechanical Engineer's (ASME).
3. American Society of Sanitary Engineering (ASSE):
   a. 1013, Performance Requirements for Reduced Pressure Principle Backflow Preventers and Reduced Pressure Fire Protection Backflow Preventers.
   b. 1015, Performance Requirements for Double Check Backflow Prevention Assemblies and Double Check Backflow Fire Protection Assemblies.
4. American Water Works Association (AWWA):
   a. C510, Double Check Valve Backflow Prevention Assembly.
   b. C511, Reduced-Pressure Principle Backflow Prevention Assembly.
   c. C550, Protective Interior Coatings for Valves and Hydrants.
5. ASTM International (ASTM):
   a. A48/A48M, Standard Specification for Gray Iron Castings.
   b. D4101, Standard Specification for Polypropylene Injection and Extrusion Materials.
6. Canadian Standards Association (CSA):
   a. B64.4, Backflow Preventers, Reduced Pressure Principle Type (RP).
   b. B64.5, Backflow Preventers, Double Check Valve Type (DCVA).
7. FM Global (FM).
8. Food and Drug Administration (FDA).
9. Foundation for Cross-Connection Control and Hydraulic Research at University of Southern California (FCCHR): Manual of Cross-Connection Control.
10. International Code Council (ICC): International Plumbing Code (IPC).
11. National Electrical Code (NEC).
12. National Electrical Manufacturers Association, (NEMA): MG 1, Motors and Generators.

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13. NSF International (NSF):
    a. NSF/ANSI 61, Drinking Water System Components - Health Effects.
    b. NSF/ANSI 372, Drinking Water System Components - Lead Content.
14. Underwriters Laboratories Inc. (UL).

1.02 SUBMITTALS

A. Action Submittals:

1. Manufacturer's product data.
2. Seismic anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.

B. Informational Submittals:

1. Seismic anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Component and attachment testing seismic certificate of compliance as required by Section 01 45 33, Special Inspection and Testing.
3. Performance test report for submersible pump.

1.03 SPECIAL GUARANTEE

A. Where note below, provide manufacturer's extended guarantee in writing with Owner named as beneficiary. Special guarantee shall provide for correction, or at the option of the Owner, removal and replacement of products found defective during the stated period after date of Substantial Completion.

PART 2 PRODUCTS

2.01 GENERAL

A. Components and Materials in Contact with Water for Human Consumption: Comply with the requirements of the Safe Drinking Water Act and other applicable federal, state, and local requirements. Provide certification by manufacturer or an accredited certification organization recognized by the Authority Having Jurisdiction that components and materials comply with the maximum lead content standard in accordance with NSF/ANSI 61 and NSF/ANSI 372.

1. Use or reuse of components and materials without a traceable certification is prohibited.

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2.02 WATER HEATERS

A. Electric Water Heater (Commercial):

1. Description:
   a. Automatic, vertical, electric storage type.
   b. Regulatory Compliance: UL listed, ASME, ASHRAE 90.1, and NSF.
   c. Tank: Steel, glass-lined or Aqua Plex stainless steel, 150 psig working pressure, and ASME rate.
   d. Insulation: Foam or fiberglass type with minimum R value per ASHRAE 90.1.
   e. Dip Tube: Required on inlet connection down to bottom section of tank for glass-lined tanks.
   f. Anode: Heavy-duty, tank-mounted, screw-in type.
   g. Pressure/Temperature Relief Valve: ASME rated.
   h. Connections: Inlet and outlet with factory-installed dielectric unions and brass drain valve with hose thread.
   i. Heating Element: Watt-density (maximum of 75 watts per square inch) incoloy sheath; immersion type.
   j. Controls: Fully automatic, house in hinged control panel, and including the following:
      1) Terminal block.
      2) Close differential immersion-type thermostat.
      3) Control transformer for 120-volt circuit and fusing.
      4) Magnetic contactors for each stage.
      5) Manual reset high-limit switch.
      6) Adjustable temperature range, 95 degrees F to 180 degrees F.
      7) Power circuit fusing as required by NEC and UL.
   k. Guarantee: 6 years.
2. Capacity: See data sheet at end of section.
3. Manufacturers:
   a. AO Smith.
   b. Bradford White Corporation.
   c. Lochinvar Corporation.
   d. PVI.

2.03 DOMESTIC WATER EXPANSION TANK

A. Description:

1. Type: Prepressurized diaphragm type, horizontal or vertical per expansion tank data sheet at end of section.
2. Shell: Welded steel.
3. Diaphragm: FDA-approved, heavy-duty butyl with polypropylene liner.

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4. Connection Size: Per expansion tank data sheet at end of section.
5. Maximum Operating Pressure: Per expansion tank data sheet at end of section.
6. Maximum Operating Temperature: Per expansion tank data sheet at end of section.
7. Finish: Manufacturer's standard air-dry enamel.

B. Capacity: See data sheet at end of section.

C. Manufacturer:

1. AMTROL, Inc.; Model AST.
2. TACO, Model PAX.

2.04 DOMESTIC HOT WATER CIRCULATING PUMP

A. Description:

1. Type: In-line, direct-drive, close-coupled centrifugal pump.
2. Construction: Bronze body, stainless steel face plate, glass-filled noryl impeller, carbon steel shaft, mechanical carbon on ceramic seals, and bronze oil lubricated motor bearings.
3. Motor: Permanent split-capacitor with thermal overload protection.
4. Accessories: Aquastat and automatic timer kit.

B. Capacity: See data sheet at end of section.

C. Manufacturers:

1. Bell & Gossett.
2. Taco, Inc.
3. Grundfos Pump Corporation.

2.05 DOMESTIC WATER BOOSTER PUMP SYSTEM

A. Description:

1. General: Complete packaged triplex booster pump system, including pumps, hydromatic tank, controls, control panel, piping, valves, and appurtenances, factory assembled, skid mounted, prewired, and tested.
2. Pumps: End suction, close coupled, or base mounted, centrifugal. See data sheet at end of section.
3. Hydromatic Tank:
   a. Prepressurized diaphragm type per data sheet at end of section.
   b. Shell: Welded steel, ASME rated and stamped.

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c. Diaphragm: FDA approved, replaceable heavy-duty butyl with polypropylene liner with complete separation between water and shell.
d. Maximum Operating Pressure: 125 psig.
e. Maximum Operating Temperature: 125 degrees F.
f. Finish: Manufacturer's standard air-dry enamel.
g. Accessories: Supports, bladder access flange, drain, air-charging valve, and lifting lug.

4. Piping:
   a. Material: Schedule 40 stainless steel.
   b. Fittings: Screwed or flanged for 2 inches and smaller, flanged and welded for 2-1/2 inches and larger.
   c. Gasket Material: FDA approved.
   d. Isolation Valves: Full port ball or butterfly type.
   e. Pump Check Valves: Combination pressure-reducing and nonslam type.
   f. Pressure Gauges: 4-1/2-inch dial, 2 percent accuracy, stainless steel bourdon tube with snubber and gauge cock valve.
   g. Flow Gauge: Pipeline-mounted flow sensor with visual indication.
5. Controls:
   a. Control Panel: UL listed, NEMA 1 enclosure, single point electrical connection.
   b. Starter: Magnetic, across the line with thermal overload.
   c. Control Switch: ON/OFF/AUTO switch for each pump with indicating lights.
   d. Alarms: Audio and visual.
   e. Pump Alternation: Automatic lead/lag control based on pressure transducer, including automatic transfer on pump failure.
   f. Safety Controls: Thermal resets, low-suction pressure cutout.
   g. Flow Sequencing: Automatic, 5-step control.
   h. Pressure Monitoring and Control System: Completely redundant for failure of primary system.

B. Capacity: See data sheet at end of section.

C. Manufacturers:

1. Bell & Gossett.
2. Paco Pumps.
3. SyncroFlo.

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2.06 SUBMERSIBLE CENTRIFUGAL SUMP PUMPS

A. Simplex, Submersible Sump Pump:

1. Description:
   a. Type: Simplex, heavy-duty, nonclog, close-coupled submersible centrifugal sump pump.
   b. Volute: Cast iron, foot mounted.
   c. Impeller: Cast iron.
   d. Motor Enclosure: Cast iron, Buna-N O-ring seals with corrosion-resistant exterior finish.
   e. Motor: Continuous-duty, built-in thermal overload protection.
   f. Shaft Seals: Tandem, mechanical type.
   g. Shaft: Stainless steel.
   h. Bearings: Permanently lubricated, ball bearing with B-10 bearing life of 17,500 hours.
   i. Electrical: Inner seal chamber with 2 moisture sensing probes and attached power and control cables, with length, voltage, and power requirements as indicated on data sheet at end of section.
   j. Controls:
      1) Circuit Breakers: Motor rated.
      2) Motor Starters: Magnetic with thermal overload protection device.
      3) Level Control: Polypropylene-encapsulated mechanical float switch.
      4) Leak Detection: Pump seal alarm circuit.
2. Capacity: See data sheet at end of section.
3. Manufacturers:
   a. Hydromatic Pumps.
   b. Paco Pump.
   c. Weil Pump Company, Inc.
   d. Liberty.

B. Duplex, Column Type, Sump Pump (Acid-Resistant):

1. Construction:
   a. Impeller and Volute: PVC construction with stainless steel inserts.
   b. Motor Support Bracket: Cast iron, epoxy coated.
   c. Shaft: Stainless steel with PVC sleeve.
   d. Bearings: Lower and intermediate ceramic bearings with vapor seals. Upper bearing shall be external and allow shaft adjustment.
   e. Column: Ribbed PVC construction.
   f. Strainer: PVC construction with 1/4-inch diameter holes.
   g. Motor: Vertical mounted, C-face, open drip-proof (ODP), premium-efficiency, ball bearing design.

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2. Sump and Cover Plate: Cylindrical design, PVC construction, vaportight with subplates and openings.
3. Controller:
    a. Float: Adjustable, rising rod, PVC construction, fume-tight design. High-level indicator light, dry contacts for remote alarm, alarm horn, and alarm acknowledge.
    b. Control Panel: NEMA 4 enclosure with fusible disconnect switch, HOA (HAND/OFF/AUTO) selector switch. Panel mounted indicator lights for “power on” and “pump off.”
    c. Motor Protection: Magnetic motor starter with overload protection.
4. Capacity: See data sheet at end of section.
5. Manufacturer: Vanton.

2.07 BACKFLOW PREVENTERS

A. Reduced Pressure Backflow Preventers (1/4 Inch Through 1/2 Inch):

1. Description:
    a. Regulatory Compliance: AWWA C511, CSA B64.4, ASSE 1013, ICC (IPC), FM, USC-UL.
    b. Valve Body: Bronze.
    c. End Connections: Threaded, NPT.
    d. Maximum Working Pressure: 175 psi (350 psi test).
    e. Temperature Range: 32 degrees to 140 degrees F.
    f. Shutoff Valve: Full port, resilient seated, bronze ball valve with bronze ball valve test cock.
    g. Accessories: Drainline air gap fitting.
2. Sizes: See data sheet at end of section.
3. Manufacturer and Product: Conbraco Industries; Series 20-400.

B. Reduced-Pressure Backflow Preventers (3/4 Inch Through 2 Inches):

1. Description:
    a. Regulatory Compliance: AWWA C511, CSA B64.4, FCCHR of USC Section 10, ASSE 1013, ICC (IPC).
    b. Valve Body: Bronze.
    c. End Connections: Threaded, NPT.
    d. Maximum Working Pressure: 175 psi (350 psi test).
    e. Temperature Range: 32 degrees F to 140 degrees F.
    f. Shutoff Valve: Full port, resilient seated, bronze ball valve with bronze ball valve test cock.
    g. Inlet Strainer: Bronze wye strainer, 40-mesh perforated, Type 304 stainless steel.
    h. Accessories: Drainline air gap fitting.
2. Sizes: See data sheet at end of section.

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3. Manufacturers and Products:
    a. Febco; Model 860.
    b. Watts; Model 909.

C. Reduced Pressure Backflow Preventers (2-1/2 Inches Through 10 Inches):

1. Description:
    a. Regulatory Compliance: AWWA C511, CSA B64.4, FCCHR of USC Section 10, ASSE 1013, IAPMO (UPC), SBCCI.
    b. Valve Body: Ductile or cast iron, Class 125, epoxy-coated (FDA approved).
    c. End Connections: Flanged.
    d. Maximum Working Pressure: 175 psi (350 psi test).
    e. Temperature Range: 32 degrees F to 140 degrees F.
    f. Shutoff Valve: Nonrising stem, resilient seated gate valve with bronze ball valve test cock.
    g. Inlet Strainer: cast-iron wye strainer, Class 125 flanged, fusion epoxy AWWA C550 coated, perforated stainless steel screen (1/16-inch perforations on 2-1/2 inches to 4 inches; 1/8-inch perforation on 6 inches to 10 inches), threaded cap plug blowout opening.
    h. Accessories: Drainline air gap fitting.
2. Sizes: See data sheet at end of section.
3. Manufacturers and Products:
    a. Febco; Model 860.
    b. Watts; Model 909.

D. Water Meter and Meter Boxes: Refer to Section 33 12 13, Water Service Connections.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install, arrange, and connect equipment as shown on Drawings and in accordance with manufacturer’s recommendations.

3.02 FIELD QUALITY CONTROL

A. Pumps: Do not hydrostatic test pumps with mechanical seals.

B. Startup:

1. In accordance with Section 01 91 14, Equipment Testing and Facility Startup, and Section 23 05 93, Testing, Adjusting, and Balancing for HVAC.

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2. Piping Systems: Verify that flushing, cleaning, and testing has been completed prior to startup.

3.03 SUPPLEMENTS

A. Supplements listed below, following “End of Section,” are a part of this Specification.

1. Data Sheet: Electric Water Heater (Commercial).
2. Data Sheet: Domestic Water Expansion Tank.
3. Data Sheet: Domestic Hot Water Circulating Pump.
4. Data Sheet: Domestic Water Booster Pump System.
5. Data Sheet: Simplex, Submersible Sump Pump.
6. Data Sheet: Backflow Preventers.

END OF SECTION

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Electric Water Heater (Commercial)								
Tag Number	**Storage Capacity (gallons)**	**Upper Element (kW)**	**Lower Element (kW)**	**Simultaneous Element Operation**	**Voltage**	**Diameter (inches)**	**Height (inches)**	**Manufacturer, Model No.**
XX-WH-01	10	1.5	0.0	No*	208	18	18	AO Smith DEL-10
XX-WH-02	40	0.0	0.0	*	*	18	46	Lochinvar, Model ETX-040KK
XX-WH-03	50	0.0	0.0	*	*	20	46	Lochinvar, Model ETX-050KK
XX-WH-04	65	0.0	0.0	*	*	20	59	Lochinvar, Model ETX-066KK
XX-WH-05	80	0.0	0.0	*	*	22	59	Lochinvar, Model ETX-082KK
XX-WH-06	119	0.0	0.0	*	*	28	62	Lochinvar, Model ETX-120KK
XX-WH-07	200	22.5	22.5	Yes	480	34	75	PVI Model 230 L 200A-VE

Notes:

1. Heating elements available are; 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, and 6.0 kW.

2. Voltages available are; 277V/3ph, and 480V/3ph.

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Domestic Water Expansion Tank							
Tag Number	**Configuration (horiz/vert)**	**Total Volume (gallons)**	**Acceptance Volume (gallons)**	**Air Pre-charge (psi)**	**Diameter (inches)**	**Height (inches)**	**Manufacturer, Model No.**
ET-01	Vertical	2.1	0.9	12	10	9	Amtrol, Model AST-5
ET-02	Vertical	4.7	2.4	12	12	12	Amtrol, Model AST-12
ET-03	Vertical	7.6	2.4	12	12	20	Amtrol, Model AST-20
ET-04	Vertical	12.5	10.0	12	16	17	Amtrol, Model AST-30

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Domestic Hot Water Circulating Pump					
Tag Number	**Flow Rate (gpm)**	**Pressure (feet head)**	**Motor (hp)**	**Power (volts/phase)**	**Manufacturer, Model No.**
CP-01	10	10	1/12	120V/1ph	Bell & Gossett, Model LR-15B
CP-02	10	8	1/20	120V/1ph	Bell & Gossett, Model LR-20BF

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Domestic Water Booster Pump System					
Tag Number	**Flow Rate (gpm)**	**Pressure (feet head)**	**Motor (hp)**	**Speed (rpm)**	**Power (volts/phase)**
BP-01	470	190	304	1775	460 V/3 ph
BP-02	470	190	30	1775	460 V/3 ph

Hydropneumatic Tank:

Tag Number	Configuration (horiz/vert)	Total Volume (gallons)	Acceptance Volume (gallons)	Air Pre-charge (psi)	Diameter (inches)	Height (inches)
BP-01-ET	Vertical	465	150	12	48	97

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Simplex, Submersible Sump Pump						
Tag Number	**Flow Rate (gpm)**	**Pressure (feet head)**	**Motor (hp)**	**Motor Speed (rpm)**	**Power (volts/phase)**	**Manufacturer, Model No.**
SP-01	20	32	1/2	3450	120V/1ph	Liberty, 1-1/2” Series 280
SP-02	50	25	1/2	1750	120V/1ph	Weil, 1-1/2” Series 1410
SP-03	35	10	1/4	1550	120V/1ph	Hydromatic, Model SHEF25
SP-04	30	14	1/3	1550	120V/1ph	Hydromatic, Model SHEF33

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Backflow Preventers						
Tag Number	**Valve Type[1]**	**Size (inches)**	**Flow Stream**	**Maximum Operating Flow (gpm)**	**Maximum Pressure Drop (psi)**	**Manufacturer, Model No.**
BFP-01	DC	1/2	W1	3	5	Febco, Model 850
BFP-02	DC	3/4	W1	8	6	Febco, Model 850
BFP-03	DC	1	W1	17	7	Febco, Model 850
BFP-04	DC	1-1/2	W1	45	6	Febco, Model 850
BFP-05	DC	2	W1	75	6	Febco, Model 850
BFP-06	DC	2-1/2	W1	120	5	Febco, Model 850
BFP-07	DC	3	W1	175	5	Febco, Model 850
BFP-08	DC	4	W1	320	3	Febco, Model 850
BFP-09	DC	6	W1	700	3	Febco, Model 850
BFP-10	DC	8	W1	1200	3	Febco, Model 850
BFP-11	DC	10	W1	1900	5	Febco, Model 850
BFP-01	RP	1/4	W1	0.75	10	Conbraco, Series 20-400
BFP-02	RP	3/8	W1	1.5	10	Conbraco, Series 20-400
BFP-03	RP	1/2	W1	3	10	Conbraco, Series 20-400
BFP-01	RP	1/2	W1	3	11	Febco, Model 825Y
BFP-02	RP	3/4	W1	8	14	Febco, Model 825Y
BFP-03	RP	1	W1	17	14	Febco, Model 825Y
BFP-04	RP	1-1/2	W1	45	12	Febco, Model 825Y

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Backflow Preventers						
Tag Number	**Valve Type[1]**	**Size (inches)**	**Flow Stream**	**Maximum Operating Flow (gpm)**	**Maximum Pressure Drop (psi)**	**Manufacturer, Model No.**
BFP-05	RP	2	W1	75	12	Febco, Model 825Y
BFP-06	RP	2-1/2	W1	120	11	Febco, Model 825Y
BFP-07	RP	3	W1	175	12	Febco, Model 825Y
BFP-08	RP	4	W1	320	9	Febco, Model 825Y
BFP-09	RP	6	W1	700	10	Febco, Model 825Y
BFP-10	RP	8	W1	1200	11	Febco, Model 825Y
BFP-11	RP	10	W1	1900	12	Febco, Model 825Y

Notes:

1. Valve Type: RP - Reduced Pressure, DC - Double Check.

2. Flow Streams: DIW - Deionized Water, FP - Fire Protection, IRR - Irrigation Water, LCW - Laboratory Cold Water, TWS - Tempered Water Supply, W1 - Potable Water, W2 - Nonpotable Water, W3 - Plant Water.

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SECTION 22 40 00
PLUMBING FIXTURES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Americans with Disabilities Act (ADA).
2. American Society of Mechanical Engineers (ASME).
3. American Society of Sanitary Engineering (ASSE): 1010, Performance Requirements for Water Hammer Arresters.
4. ASTM International (ASTM): D4101, Standard Specification for Polypropylene Injection and Extrusion Materials.
5. Food and Drug Administration (FDA).
6. NSF International (NSF):
    a. NSF/ANSI 61, Drinking Water System Components - Health Effects.
    b. NSF/ANSI 372, Drinking Water System Components - Lead Content.
7. Plumbing and Drainage Institute (PDI):
    a. Code Guide 302 and Glossary of Industry Terms.
    b. WH-201, Water Hammer Arrester Standard.
8. Underwriters Laboratories Inc. (UL).

1.02 SUBMITTALS

A. Action Submittals: Catalog information and rough-in dimensions for plumbing fixtures, products, and specialties.

1.03 REGULATORY REQUIREMENTS

A. Comply with the Americans with Disabilities Act (ADA), and local and state requirements.

PART 2 PRODUCTS

2.01 GENERAL

A. Components and Materials in Contact with Water for Human Consumption: Comply with the requirements of the Safe Drinking Water Act and other applicable federal, state, and local requirements. Provide certification by manufacturer or an accredited certification organization recognized by the Authority Having Jurisdiction that components and materials comply with the

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maximum lead content standard in accordance with NSF/ANSI 61 and NSF/ANSI 372.

1. Use or reuse of components and materials without a traceable certification is prohibited.

2.02 MANUFACTURERS

A. Fixture Trim:

1. Supply Stops and Traps:
   a. McGuire.
   b. American Standard.
   c. Kohler.
2. Flush Valves: Sloan.
3. Water Closet Seats:
   a. Bemis.
   b. Church.
   c. Olsonite.
4. Lavatory Supply, Tailpiece, and Trap Insulation:
   a. McGuire.
   b. Trap Wrap.
   c. Truebro.

B. Plumbing Fixtures:

1. Water Closets, Lavatories, and Urinals:
   a. American Standard.
   b. Kohler.
   c. Eljer.
2. Service Sinks:
   a. Kohler.
   b. Eljer.
3. Faucet Fittings:
   a. Sinks:
      1) Chicago.
      2) T&S Brass.
   b. Lavatories:
      1) Chicago.
      2) Symmons.
4. Shower Trim:
   a. Symmons.
   b. Powers.
5. Shower Stalls:
   a. Aqua Glass.
   b. Fixture Manufacturers.

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6. Stainless Steel Sinks:
    a. Elkay.
    b. Just.
7. Mop Sinks:
    a. Stern-Williams.
    b. Fiat Products Inc.
    c. Fixture Manufacturers.
8. Drinking Fountains and Electric Water Coolers:
    a. Elkay.
    b. Haws.
    c. Western.

C. Emergency Showers and Eyewashes:

1. Haws.
2. Western.
3. Guardian.

D. Drainage Products:

1. General:
    a. Smith.
    b. Wade.
    c. Zurn.
2. Acid Resistant:
    a. Enfield.
    b. R&G Sloane.
    c. T&C Plastic Drain Co.

E. Plumbing Specialties:

1. Shock Arresters:
    a. Smith.
    b. Sioux Chief.
    c. Precision Plumbing Products.
2. Trap Primers:
    a. Precision Plumbing Products.
    b. Smith.
    c. Wade.
3. Pressure/Temperature Relief Valves:
    a. Cash-Acme.
    b. Kunkle Valve.
    c. Watts.

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4. Pressure Gauges:
    a. Ashcroft.
    b. Marsh.
    c. Marshalltown.
5. Thermometers:
    a. Trerice.
    b. Weksler.
6. Automatic Washer Supplies:
    a. Guy Gray.
    b. Symmons.

2.03 GENERAL

A. Fixture Trim: Provide plumbing fixture trim where applicable on fixtures.

B. Plumbing Fixtures: Indicated by fixture number as shown on Drawings.

C. Drainage Products: Indicated by fixture number as shown on Drawings.

D. Plumbing Specialties: Indicated by fixture number as shown on Drawings.

E. Exposed fixture connections and piping shall be polished chrome-plated.

2.04 MATERIALS

A. Fixture Trim:

1. Supply Stop:
    a. Flexible supply with heavy cast brass, loose key, 1/2-inch IPS by 3/8-inch outside diameter tubing angle stop to wall with escutcheon plate; chrome-plated finish.
    b. Provide stop with stuffing box.
    c. Manufacturer: McGuire Manufacturing Company, Inc.
2. Trap:
    a. Chrome-plated, 17-gauge, semicast P-trap with compression ring cast brass waste and vent connection and cleanout.
    b. 1-1/2 inches for lavatories and drinking fountains.
    c. 1-1/2 inches for sinks.
    d. Manufacturer: McGuire Manufacturing Company, Inc.
3. Water Closet and Urinal Flush Valves: Sloan Valve Co., Royal Continental, low flush, quiet action with screwdriver stop and vacuum breaker.

B. Plumbing Fixtures:

1. EWC-1, Electric Water Cooler (ADA Compliant, Dual Height):
    a. Finish: Stainless steel basin, vinyl clad steel cabinet.

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b. Valve: Front pushbutton operated with automatic stream regulation.
c. Trim: Screwdriver stop, strainer, and P-Trap with cleanout.
d. Cooler: R134 refrigerant. air cooled.
e. Mount: Wall mounting.
f. Maunfacturer: Elkay model LZSTL8

2. LAV-1, Lavatory (Wall-Hung Type, ADA Compliant):
   a. Fixture: 20 inches by 18 inches, vitreous china, for floor-mounted concealed arm carrier, single-hole punched for faucet; additional hole for soap dispenser. American Standard Companies, Inc.; Lucerne, Model 0356.421.
   b. Faucet: American Standard; Model 6056.104 with ASSE 1070 mixing valve.
   c. Trim: 3/8-inch supply stop with loose key, 17-gauge chrome-plated cast brass P-trap.
   d. Insulation: McGuire Manufacturing Company, Inc., Prowrap antimicrobial PVC resin seamless insulation for trap, tailpiece, and hot and cold water supply piping.
   e. Strainer: McGuire Manufacturing Company, Inc.; Model 155A chrome-plated grid strainer with tailpiece.
   f. Carrier: Jay R. Smith Mfg. Co.; 700 series concealed arm.
   g. AC power with low voltage transformer.
   h. AC Powered Soap Dispenser: Sloan; Model ESD-200.
3. LAV-2, Lavatory (Wall-Hung Type, ADA Compliant):
   a. Fixture: 20 inches by 18 inches, vitreous china, for floor-mounted concealed arm carrier, three-hole punched on 8-inch centers for faucet additional hole for soap dispenser. American Standard Companies, Inc.; Lucerne, Model 0356.015.
   b. Faucet: Chicago Faucet Co.; Model 786-GN2-FCCP with 0.5-gpm flow control and rigid/swing gooseneck spout.
   c. Trim: 3/8-inch supply stop with loose key, 17-gauge chrome-plated cast brass P-trap.
   d. Insulation: McGuire Manufacturing Company, Inc., Prowrap antimicrobial PVC resin seamless insulation for trap, tailpiece, and hot and cold water supply piping.
   e. Strainer: McGuire Manufacturing Company, Inc.; Model 155A chrome-plated grid strainer with tailpiece.
   f. Carrier: Jay R. Smith Mfg. Co.; 700 series concealed arm.
4. LAV-3, Lavatory (Counter Set, Oval):
   a. Fixture: 20 inches by 17 inches, vitreous china, self-rimming. American Standard Companies, Inc.; Aqualyn, Model 0476.047.
   b. Faucet: American Standard; Model 6056.104 with ASSE 1070 mixing valve.
   c. Trim: 3/8-inch supply stop with loose key, 17-gauge chrome-plated cast brass P-trap.

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d. Insulation: McGuire Manufacturing Company, Inc.; Prowrap antimicrobial PVC resin seamless insulation for trap, tailpiece, and hot and cold water supply piping.
e. Strainer: McGuire Manufacturing Company, Inc.; Model 155A chrome-plated grid strainer with tailpiece.
f. AC power with low voltage transformer.
g. AC Powered Soap Dispenser: Sloan; Model ESD-200.

5. MS-1, Mop Sink (Floor Mounted):
   a. Fixture: Stern-Williams Co. Inc.; Model HL-1800-BP; Molded stone, 24 inches by 24 inches by 12 inches deep with stainless steel bumper guard, back panels and chrome-plated brass drain.
   b. Faucet: Chicago Faucet Co.; Model 897-CP, concealed supplies with hose threads, vacuum breaker, and rod support. Faucet mounted 36 inches above finish floor.
   c. Accessories: Stern-Williams Co. Inc.; T-35 hose and T-40 stainless steel mop hanger.
6. MS-2, Mop Sink (Floor Mounted):
   a. Fixture: Molded stone, corner set, 24 inches by 24 inches by 12 inches deep with stainless steel bumper guard, back panels and chrome-plated brass drain. Stern-Williams Co. Inc.; Model SBC-1700-BP.
   b. Faucet: Chicago Faucet Co.; Model 897-CP, concealed supplies with hose threads, vacuum breaker, and rod support. Faucet mounted 36 inches above finish floor.
   c. Accessories: Stern-Williams Co. Inc.; Model T-35 hose and T-40 stainless steel mop hanger.
7. S-1, Sink (Counter, Stainless Steel, Single Compartment):
   a. Fixture: 21 inches by 25 inches overall by 8 inches deep, 18-gauge, Type 304 stainless steel, three-hole punch, self-rimming, undercoated, ledge-type. Just Mfg. Co.; Model SL-2125-A-GR.
   b. Faucet: **[K: Chicago Faucet Co.; Model 2300-8 single handle with 8-inch cover plate.] [L: Chicago Faucet Co.; Model 1201 double handle.]**
   c. Trim: 1-1/2-inch outside diameter, 17-gauge chrome-plated cast tailpiece and cast brass P-trap with cleanout, and 1/2-inch wall supply stop with loose key.
   d. Strainer: Just Mfg. Co.; Model J-35, stainless steel crumb-type.
   e. **[M: Disposer: IES (In-Sink-Erator); Model 77, 3/4 horsepower, stainless steel.]**
   f. **[N: Hot Water Dispenser: ISE (In-Sink-Erator); Model GN, 190 degrees.]**

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8. S-2, Sink (Counter, Stainless Steel, Double Compartment):
    a. Fixture: 21 inches by 33 inches overall by 8 inches deep, 18-gauge, Type 304 stainless steel, four-hole punch, self-rimming, undercoated, ledge-type. Just Mfg. Co.; Model DL-2133-A-GR.
    b. Faucet: Chicago Faucet Co.; Model 1102-L9E35-369ABCP lever handle with 8-inch cover plate and side spray.
    c. Trim: 1-1/2-inch outside diameter, 17-gauge chrome-plated cast tailpiece and cast brass P-trap with cleanout, and 1/2-inch wall supply stop with loose key.
    d. Strainer: Just Mfg. Co.; Model J-35, stainless steel crumb-type.
    e. Disposer: IES (In-Sink-Erator); Model 77, 3/4 horsepower, stainless steel.
9. S-3, Sink (Small Coffee, Bar Sink):
    a. Fixture: 15 inches by 15 inches by 9 inches deep, 18-gauge, Type 304 stainless steel, self-rimming, undercoated, ledge-type. Just Mfg. Co.; Model SBX-1515-A-GR.
    b. Faucet: **[S: Chicago Faucet Co.; Model 2302, side valve with gooseneck spout. Faucet mounted on counter.] [T: Chicago Faucet Co.; Model 895; dual lever handles with GN2A gooseneck spout. Faucet mounted on counter.]**
    c. Trim: 1-1/2-inch outside diameter, 17-gauge chrome-plated cast tailpiece and cast brass P-trap with cleanout, and 1/2-inch wall supply stop with loose key.
    d. Strainer: Just Mfg. Co.; Model J-35; stainless steel crumb-type.
10. S-4, Sample Sink (Single Compartment, Free Standing):
    a. Fixture: 24 inches by 24 inches by 14 inches deep, 14-gauge, Type 304 stainless steel, 8-inch backsplash, adjustable stainless steel tubular legs. Elkay Mfg. Co.; Model SS-8124.
    b. Faucet: Short spout with vacuum breaker, 3/4-inch hose thread outlet, pail hook, H supply arms, 4-inch to 8-3/8-inch adjustable centers, lever handles. Faucet mounted on backsplash. Chicago Faucet Co.; Model 305-VB.
    c. Trim: 1-1/2-inch outside diameter, 17-gauge chrome-plated flat strainer, tailpiece, and cast brass P-trap with cleanout, and 1/2-inch wall supply stop with loose key. Elkay Mfg. Co.; Model LK-18.
11. SH-1, Shower (Stall, ADA Compliant):
    a. Enclosure: FreedomShowers, Model APFQ3682BF625 acrylic enclosure complete with fold-down seat, grab bars, and chrome-plated drain.
    b. Showerhead: Sloan Valve Co.; Model AC-11-B-2.0, with 2.0-gpm flow restricter.
    c. Hand Spray: 2.0-gpm flow restricter, 60-inch flexible stainless steel hose with in-line vacuum breaker, quick disconnect, and 24-inch chrome-plated glide bar.

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d. Mixing Valve: Powers Process Control; Model E707, T/P type.
e. Trim: Inlet strainer, check, integral stop, temperature limit stop, two wall hooks, and diverter valve.

12. UR-1, Urinal (Flush Valve, Wall-Hung Type):
    a. Fixture: Vitreous china, siphon jet action with flushing rim, top spud. American Standard Companies, Inc.; Allbrook 0.5, Model 6550.510.
    b. Trim: Sloan Valve Co.; Royal Optima, Model 186-0.5 ES-S, 0.5 gallon per flush with 24-volt infrared sensor, Model EL-1500; 24-volt solenoid operator and 120 volt/24 volt, UL listed transformer, Model EL-154.
    c. Carrier: Jay R. Smith Mfg. Co.; Figure 644, commercial floor-mounted type.
13. UR-2, Urinal (Flush Valve, Wall-Hung Type, ADA Compliant): Same as UR-1, but mounted for access meeting ADA requirements.
14. WC-1, Water Closet (Flush Valve, Wall-Hung Type):
    a. Fixture: Vitreous china, siphon jet action, top spud, elongated bowl. American Standard Companies, Inc.; Afwall EL 1.28 Model 2257.712.
    b. Trim: Sloan Valve Co.; Royal Optima, Model 111-1 ES-S, 1.28 gallon per flush with 24-volt infrared sensor, Model EL-1500-L; 24-volt solenoid operator and 120 volt/24 volt, UL listed transformer, Model EL-154.
    c. Seat: Olsonite Corp.; 10-CC-SS; white open front.
    d. Carrier: Jay R. Smith Mfg. Co.; Model 200/400, commercial type.
15. WC-2, Water Closet (Flush Valve, Wall-Hung Type, ADA Compliant): Same as WC-1 but mounted for handicap access with flush valve handle pointed to wide side of stall enclosure and meeting ADA requirements.

C. Safety Equipment:

1. SSH-1, Safety Shower/Eyewash Combination:
    a. Model: Haws Drinking Faucet Co.; Model 8346.
    b. Shower: ABS plastic deluge.
    c. Eyewash: Stainless steel bowl with aerated eye/face wash.
    d. Valve: Stay open.
    e. Support: Freestanding, 1-1/4-inch galvanized pipe standard, stanchion, and floor flange.
    f. Alarms: Magnetically operated proximity switches.
    g. Factory applied CRP (corrosive atmospheres coating).
2. SSH-2, Safety Shower/Eyewash Combination (Freeze-proof):
    a. Model: Haws Drinking Faucet Co.; Model 8317CTFPT.
    b. Shower: ABS plastic deluge.
    c. Eyewash: Stainless steel bowl with aerated eye/face wash.
    d. Valve: Stay open.

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e. Support: Freestanding, 1-1/4-inch galvanized pipe standard, stanchion, and floor flange, cable heated and insulated.
f. Alarms: Magnetically operated proximity switches.

D. Drainage Products:

1. CO-1, Cleanout (Exterior):
   a. Material: Taper thread, bronze plug, heavy-duty, scoriated cast-iron top.
   b. Manufacturer and Product: Jay R. Smith Mfg. Co.; Model 4263.
2. CO-2, Cleanout:
   a. Material: Taper thread, bronze plug, scoriated nickel bronze top.
   b. Manufacturer and Product: Jay R. Smith Mfg. Co.; Model 4023.
3. FCO-1, Floor Cleanout (Finished Areas):
   a. Material: Tapered thread, bronze plug with round adjustable scoriated secured nickel bronze top.
   b. Manufacturer and Product: Jay R. Smith Mfg. Co.; Model 4103S.
4. FCO-2, Floor Cleanout (Unfinished Areas):
   a. Material: Tapered thread, bronze plug with round adjustable scoriated secured cast-iron top.
   b. Manufacturer and Product: Jay R. Smith Mfg. Co.; Model 4243S.
5. FCO-3, Floor Cleanout (Acid Resistant):
   a. Material: Polypropylene conforming to ASTM D4101.
   b. Ferrule supplied with countersunk plug and adjustable top with round cover, with Acid Waste Cleanout (AWCO) cast in the cover.
   c. Manufacturer and Product: Orion Fittings Inc.; Model FCO-RD.
6. FD-1, Floor Drain (Finished Areas):
   a. Materials: Cast-iron body, adjustable nickel bronze strainer.
   b. Options: Jay R. Smith Mfg. Co.; Model 2696, trap primer connection, vandalproof screws.
   c. Manufacturer and Product: Jay R. Smith Mfg. Co.; Model 2005T-U-round.
7. FD-2, Floor Drain (Unfinished Areas, General Drainage):
   a. Materials: Cast-iron body and grate.
   b. Options: Sediment bucket, Jay R. Smith Mfg. Co.; Model 2696, trap primer connection, vandalproof screws.
   c. Manufacturer and Product: Jay R. Smith Mfg. Co.; Model 2210T-U.
8. FD-3, Floor Drain (Unfinished Areas, Heavy Drainage):
   a. Materials: Cast-iron body and grate.
   b. Options: Sediment bucket, Jay R. Smith Mfg. Co.; Model 2696, trap primer connection, vandalproof screws.
   c. Manufacturer and Product: Jay R. Smith Mfg. Co.; Model 2233T-U.

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9. FD-5, Floor Drain (Indirect Receptor):
    a. Materials: Cast-iron body and strainer.
    b. Options: Round top, antiflood rim strainer, Jay R. Smith Mfg. Co.; with integral trap primer connection, vandalproof screws.
    c. Manufacturer and Product: Jay R. Smith Mfg. Co.; Model 2010T-U-F37.
10. FD-6, Floor Drain (Acid Resistant):
    a. Materials: Acid-resistant polypropylene with flame-retardant body, integral flange with clamping collar, basket strainer, and top grate.
    b. Model: T & C Plastic Drain Co., Inc.; Model PP-7749 (2 inches), PP-7750 (3 inches), PP-7751 (4 inches).
11. HD-1, Hub Drain:
    a. Coated cast-iron reducing hub adapter with standard cast-iron hub.
    b. Hub: Two pipe sizes larger than outlet.
12. WCO, Wall Cleanout:
    a. Material: Stainless steel cover and screw.
    b. Manufacturer and Product: Jay R. Smith Mfg. Co.; Model 4472.

E. Hose Valves: Refer to Section 22 10 01, Plumbing Piping and Accessories.

F. Plumbing Specialties:

1. Water Hammer Arresters:
    a. Materials: ASSE 1010 certified, Type L copper tube, HHPP piston with two lubricated EPDM O-rings, FDA approved lubricant, rolled piston stop, wrought copper male thread adapter.
    b. Manufacturer and Product: Sioux Chief Mfg. Co., Inc.; Series 650 and 660.
2. TP-1, Trap Priming Valve:
    a. Materials: Cast bronze, line pressure drop activated, antisiphon port, 1/2-inch connection.
    b. Manufacturer and Product: Precision Plumbing Products, Inc.; Model P-1 trap priming valve and Model DU-4, distribution unit.
3. TP-2, Trap Priming Valve:
    a. Materials: Cast bronze, line pressure drop activated, antisiphon port, 1/2-inch connection.
    b. Manufacturer and Product: Jay R. Smith Mfg. Co.; Figure 2699.
4. ETP-1, Automatic Trap Priming System:
    a. Materials: Electronic controller, manual override switch, solenoid valve, 1/2-inch connection, calibrated water distribution manifold, and air gap.
    b. Power: 120V, single-phase.

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c. Manufacturer and Product: Precision Plumbing Products, Inc.; Model MP-500.

5. ETP-2, Automatic Trap Priming System:
   a. Materials: Preset 24-hour clock, manual override switch, solenoid valve, 3/4-inch connection, calibrated water distribution manifold, water hammer arrester, and wall-mounted steel cabinet with access door.
   b. Power: 120V, single-phase.
   c. Manifold outlet quantity as required.
   d. Manufacturer and Product: Precision Plumbing Products, Inc.; Prime-Time Model PT.
6. ETP-3, Energy Management Controlled Trap Priming Valve with Solenoid:
   a. Materials: Solenoid valve, air gap assembly and receiver, 6-foot cord.
   b. Manufacturer and Product: Precision Plumbing Products, Inc.; Solo Prime.
7. Pressure/Temperature Relief Valve:
   a. Materials: ASME/AGA rated, bronze body construction, vacuum relief valve vent in drain, backup emergency safety fuse plug, tamper-resistant bonnet screws, test lever, short thermostat, and automatic reseating.
   b. Manufacturer and Product: Watts Industries, Inc.; Series 40.
8. Pressure Gauge:
   a. Materials: 3-1/2-inch gauge size, 0 to 160 psi range, steel case, glass crystal, brass movement, and 1/3-inch NPT lower connection.
   b. Manufacturer and Product: Ashcroft Dresser Instrument Division, Dresser Industries, Inc.; Type 1008.
9. Thermometer:
   a. Materials: Adjustable angle, red reading mercury type with 9-inch case and 30 degrees F to 180 degrees F range, 3-1/2-inch aluminum stem, and separate NPT brass thermowell.
   b. Manufacturer and Product: H.O. Trerice Co.; Model A005.
10. WS-1, Automatic Washer Supply:
    a. Materials: Recessed box with 2-inch drain connection, single lever shutoff with 1/2-inch hot and cold water connections, and with shock arresters on both hot and cold water supplies.
    b. Manufacturer and Product: Guy Gray Manufacturing Co. Specialty Products; Model WB-200HA.

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11. IB-1, Icemaker Box:
    a. Recessed polystyrene box with support brackets, 1/4-turn brass ball valve.
    b. Manufacturer and Product: Oatey; 38681.

G. Sealant: In accordance with Section 07 92 00, Joint Sealants.

PART 3 EXECUTION

3.01 PREPARATION

A. Drawings do not attempt to show exact details of fixtures. Changes in locations of fixtures, advisable in opinion of Contractor, shall be submitted to Engineer for review before proceeding with the Work.

3.02 INSTALLATION

A. Fixture Trim: Install fixture trim where applicable on fixtures.

B. Plumbing Fixtures, Mounting Heights:

1. Standard rough-in catalogued heights, unless shown otherwise on Drawings.
2. Caulk fixtures in contact with finished walls with waterproof, white, nonhardening sealant which will not crack, shrink, or change color with age. See Section 07 92 00, Joint Sealants.

C. Exact fixture location and mounting arrangement shall be as indicated on toilet room elevations and details as shown on Drawings.

D. Unless noted otherwise and as a minimum, fixtures shall be supported as indicated in PDI Code Guide 302.

E. Safety Equipment:

1. System Shutoff Valves:
    a. Shutoff valves shall give visual indication of position (open or closed).
    b. Shutoff valves shall be lockable valves and locked in open position.
2. Each safety shower, eyewash, combination safety shower/eyewash shall have red safety signoff tag. After completing requirements listed below, Contractor and Owner shall sign red safety signoff tag. Requirements are as follows:
    a. Visually check safety shower/eyewash piping for leaks.
    b. Verify that upon operation, stay-open valves remain open.

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c. Showerheads to be between 82 inches and 96 inches above standing surface.
d. Shower spray pattern, when valve is full open, shall be a minimum 20 inches in diameter at 60 inches above standing surface.
e. Water arcs from eyewash spray heads must cross. Test with eyewash gauge; Haws Drinking Faucet Co., Model 9015.
f. Minimum flow rates for safety showers shall be 20 gpm.
g. Minimum flow rates for eyewashes shall be 3 gpm.
h. Tempered water shall be temperature indicated on Drawings.

F. Drainage Products:

1. Floor Drains: Set top flush with floor. Provide membrane clamps where required.
2. Cleanouts: Install where shown or required for purposes intended. Set cover flush with finished floor.
3. Hub Drains: Set top of hub 2 inches above finished floor.

G. Plumbing Specialties:

1. Shock Arresters:
   a. Install PDI-certified and rated shock arresters, sized and located in accordance with PDI WH-201 and as shown on Drawings.
   b. Install adjacent to equipment wherein quick closing valves are installed.
   c. Install at each emergency safety shower.
   d. Shock arresters to have access panels or to be otherwise accessible.
2. Drain P-Trap Priming:
   a. Pipe: Type K, soft copper.
   b. Trap and prime floor drains and hub drains, unless shown otherwise on the Drawings. No attempt has been made to show trap primer valve locations or trap primer pipe routing.
   c. Field route trap primer piping during installation of floor drains and hub drains, and install trap primer valves in mechanical rooms, janitor rooms, or other locations acceptable to Engineer.
   d. Priming System: Complete with connection to serving cold water system.
3. Trap Priming Valves:
   a. Floor drain traps primed with priming valves, 1/2-inch copper to floor drain.
   b. Two traps maximum primed from one priming valve or as recommended by manufacturer. Locate in mechanical spaces or janitor’s rooms and as indicated on Drawings.
   c. Provide shutoff valve ahead of priming valves.

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4. Thermometers and Pressure Gauges:
    a. Arrange devices to facilitate use and observation.
    b. Install in orientation that will allow clear observation from ground level.
    c. Provide pressure gauges with block valves.
    d. Install thermometers in thermowells.

H. Caulk penetrations of exterior walls with weatherproof sealant in accordance with Section 07 92 00, Joint Sealants.

I. Adjust water flows in domestic water systems for reasonable water flows at each plumbing fixture, terminal device, and recirculation loop. Flush valve fixtures shall be adjusted for proper flush cycle time and water quantity.

3.03 FIELD QUALITY CONTROL

A. Perform visual inspection for physical damage, blocked access, cleanliness, and missing items.

B. Notify Owner and Engineer 48 hours prior to shower testing. Owner and Engineer reserve the right to witness all tempered water and safety shower testing.

C. Test safety shower and eyewash units. Water flow must be tested at both showerhead and eyewash/face ring.

1. Shower Flow:
    a. Test with tube-type water gauge (Haws Drinking Faucet Co., Model 9010) and 5-gallon container.
    b. Container shall fill in 10 seconds or less, with a minimum 20-gpm flow.
2. Eyewash Flow:
    a. Test with tube-type water gauge (Haws Drinking Faucet Co., Model 9010) and 1-gallon container.
    b. Container shall fill in 20 seconds or less.
3. Contractor shall log, date, and initial inspection upon passing flow tests.

D. Verify alarm operation both locally and systemwide. Notify security prior to test if alarm is connected systemwide.

END OF SECTION

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SECTION 23 05 14
HVAC ADJUSTABLE FREQUENCY DRIVES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Federal Communications Commission Regulations (FCC).
2. International Electro-technical Commission (IEC): 60146, Semiconductor Converters.
3. Institute of Electrical and Electronics Engineers (IEEE):
   a. 519, Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems.
   b. C62.41, Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits.
4. National Electrical Code (NEC).
5. National Electrical Manufacturer's Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
   b. CP 1, Shunt Capacitors.
   c. ICS 7.1, Safety Standards for Construction and Guide for Selection, Installation, and Operation of Adjustable Speed Drive Systems.
   d. MG 1, Motors and Generators.
   e. WC 57, Standard for Control Cables.
6. National Fire Protection Association (NFPA): Electrical Standard for Industrial Machinery.
7. Underwriters Laboratories, Inc. (UL): 508C, Safety Power Conversion Equipment.

1.02 DEFINITIONS

A. This section includes variable speed motor controls referred to as Adjustable Frequency Drives (AFD); also known as Variable Frequency Drives (VFD), Variable Speed Drives (VSD), and Adjustable Speed Drives (ASD).

B. The following is a list of terms that may be used in this section:

1. ac: Alternating Current.
2. AFD: Adjustable Frequency Drive.
3. CMOS: Complementary Metal Oxide Semiconductor.
4. dc: Direct Current.
5. EMI: Electro-Magnetic Interference.

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6. FLA: Full Load Amps.
7. LCD: Liquid Crystal Display.
8. MPR: Motor Protection Relay.
9. MTBF: Mean Time Between Failure.
10. PID: Proportional, Integral, and Differential.
11. PWM: Pulse Width Modulation.
12. RFI: Radio Frequency Interference.
13. RTD: Resistance Temperature Detector.
14. Rated Load: Load specified for equipment.
15. Rated Speed: Nominal rated (100 percent) speed specified for equipment.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Wiring diagrams, front and side views of enclosures, overall dimensions, conduit entrance locations and requirements, nameplate legends, and enclosure details.
   b. Data sheets showing voltage, ratings and size of switching and over-current protective devices, short circuit ratings, and weights.
   c. Specific description of harmonic mitigation provisions being made to ensure proper system operation and compliance with IEEE 519.
   d. Anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.

B. Informational Submittals:

1. Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Manufacturer’s Installation Instructions:
   a. Indicate application conditions and limitations of use stipulated by product testing agency specified under regulatory requirements.
   b. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of adjustable speed drive.

1.04 QUALITY ASSURANCE

A. AFD and all associated equipment shall be UL Listed and labeled, in accordance with UL 508C.

B. AFD shall be designed, constructed and tested in accordance with NEMA, NEC, and IEC standards.

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C. AFD must meet requirements for RFI as specified by FCC regulations, Part 15, Subpart J, Class A Devices.

D. Harmonics Mitigation:

1. AFD shall meet harmonic current distortion limits of IEEE 519, measured at drive input terminals; furnish phase shift transformers, dc bus reactors, ac line reactors, harmonic filters, or other devices as necessary.
2. Furnish necessary devices and circuits to prevent operation of one drive from adversely affecting operation of other drives supplied from same transformer or same bus.
3. When isolation transformers are used, design to meet K-factor requirements of drive(s) connected.
4. Harmonics Analysis:
    a. AFD manufacturer shall perform a Harmonics Analysis for entire electrical distribution system.
    b. Use relevant ANSI standards and local power company standards to determine transformer fault and impedance values to be used in Harmonics Analysis.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, protect, and handle products to Site, under provisions of Section 01 61 00, Common Product Requirements.

B. Store in a clean, dry space. Maintain factory wrapping, or provide additional heavy canvas or heavy plastic cover, to protect units from dirt, water, construction debris, and traffic.

1.06 SPECIAL GUARANTEE

A. Provide manufacturer’s extended guarantee or warranty, with Owner named as beneficiary, in writing, as special guarantee. Special guarantee shall provide for correction, or at the option of the Owner, removal and replacement of Work specified in this Specification section found defective during a period of 1 year after the date of Substantial Completion. Duties and obligations for correction or removal and replacement of defective Work shall be as specified in the General Conditions.

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PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Components and accessories specified in this section shall be products of:

1. Yaskawa (Magnetek).
2. Robicon.
3. ABB.
4. Reliance Electric.
5. Graham.
6. AC Technology Corporation.
7. Toshiba.

2.02 EQUIPMENT SCHEDULES

A. Some specific equipment requirements are listed in Equipment Schedules. Refer to Drawings.

2.03 SERVICE CONDITIONS

A. Ambient Operating Temperature: 32 degrees F to 104 degrees F (0 degree C to 40 degrees C).

B. Storage Temperature: Minus 40 degrees F to 158 degrees F.

C. Humidity: 0 percent to 95 percent relative (noncondensing).

D. Altitude: 0 foot to 3,300 feet.

2.04 COMPONENTS

A. Ratings:

1. AC Line Voltage Variation: Minus 10 percent to plus 10 percent.
2. AC Line Frequency Variation: Minus 3 Hz to plus 3 Hz.
3. Frequency Stability: Plus or minus 0.5 percent of maximum frequency.
4. Minimum Efficiency: 97 percent drive efficiency at full speed, full load.
5. Starting Torque: 100 percent starting torque shall be available from 0.5 Hz to 60 Hz.
6. Overload Capability: 120 percent of rated FLA for 60 seconds; 180 percent of rated FLA, instantaneously.
7. Harmonic Distortion: As indicated in Article Quality Assurance.
8. Motor Audible Noise Level: When operating throughout speed range of PWM AFD, no more than 3 dB(A) above that designated in NEMA MG 1 for same motor operated at constant speed with 60 Hz supply voltage.

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9. RFI: As specified by FCC regulations, Part 15, Subpart J, Class A Devices.
10. Short Circuit Rating: Minimum 65 kA RMS, without additional input fusing.

B. Design:

1. Transform ac input power into frequency and voltage controlled three-phase output power suitable to provide positive speed and torque control to standard induction motor.
2. Employ a PWM inverter system, consisting of:
    a. Input Section:
        1) AFD input power stage shall convert three-phase ac line power into a constant dc voltage via a solid state three-phase full wave diode bridge rectifier, with MOV protection.
        2) Shall be insensitive to phase rotation of ac line.
    b. Intermediate Section:
        1) DC bus as a supply to AFD output section to maintain fixed voltage with filtering and short circuit protection.
        2) DC bus shall be interfaced with AFD diagnostic logic circuit, for continuous monitoring and protection of power components.
        3) Provide dc bus reactors and capacitor as necessary for satisfactory drive operation.
    c. Output Section:
        1) Microprocessor-controlled PWM inverter to convert dc voltage to variable voltage, adjustable frequency three-phase ac output.
        2) Inverter shall be isolated from all power circuits.
        3) Output voltage shall vary proportionally with frequency to maintain a constant ratio of volts to hertz up to 60 Hz.
        4) Above 60 Hz, voltage shall remain constant, with AFD operating in a constant horsepower output mode.
        5) Output shall be PWM sine coded.
        6) Variable frequency power and logic unit shall be solid state.
    d. Drive operation shall be stepless.
    e. Shall not induce voltage line notching back to utility line.

C. Signal Interface:

1. Analog Inputs: AFD shall include two independent remote reference inputs.
    a. One shall be 0V dc to 10V dc.
    b. Second shall be programmable for either 0V dc to 10V dc or 4 mA to 20 mA.

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c. The bias and gain of each input shall be individually programmable.

2. Digital Inputs:
   a. Provide a minimum of five multi-function input terminals, capable of being programmed to determine the function when their state is changed.
   b. These terminals shall provide a minimum of 20 functions, including, but not limited to:
      1) Remote/Local operation selection.
      2) Detection of external fault condition.
      3) Remote reset.
      4) Multi-step speed commands.
   c. Provide terminals for remote contacts, to allow starting in the automatic mode.
   d. Include one external fault input, minimum, programmable for a normally open or normally closed contact, for connection to items such as firestats and freezestats.
3. Analog Outputs:
   a. Include a 0V dc to 10V dc analog output for monitoring, or "speed tracking" AFD.
   b. 0V dc to 10V dc analog output signal shall be proportional to output frequency, output current, output power, or dc bus voltage.
4. Digital Outputs:
   a. Include one fully rated form "A" contact and one fully rated form "C" contact, capable of being programmed to determine what conditions must be met in order for them to change state.
   b. These contacts shall be rated for at least 1 amp at 250V ac.
   c. These relays shall provide an minimum of 10 functions, including, but not limited to:
      a) Speed agree detection.
      b) Low and high frequency detection.
      c) Missing frequency reference detection.
      d) Over-torque/under-torque detection.
      e) Drive running.
      f) Drive faulted.

D. Enclosure:

1. NEMA 250, Type 12 enclosure, gasketed, freestanding, enclosure for mounting against wall, completely front accessible, and hinged doors.
2. Properly sized to dissipate heat generated by AFD within limits of specified operating conditions (including ambient temperature and ambient airflow).
3. Top and bottom conduit knockouts.
4. Alphanumeric keypad and display, and operator's controls.

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5. User terminals for power and control connections.
6. Temperature controlled forced ventilation to cool AFD with air at maximum room ambient temperature of 104 degrees F.
7. Enclosure and heat-sink fans shall be readily accessible and not require removal of AFD power converter.
8. Factory Finishing:
    a. Primer: Rust-inhibiting coating.
    b. Finish: Manufacturer's standard baked enamel finish.

E. Drive Protection:

1. Loss of input signal protection, with a speed default to 80 percent of most recent speed.
2. No damage shall occur to AFD while under load if output disconnect is open.
3. Electronic thermal overload protection for both drive and motor.
4. Ground Fault Protection: AFD and motor.
5. Over-current: Instantaneous over-current trip.
6. DC under-voltage protection, 70 percent dropout.
7. DC over-voltage protection, 130 percent pickup.
8. Over-temperature: Drive, inverter, converter, and dc link components.
9. Over-temperature: Motor and driven equipment.
10. Single-phase protection.
11. Reset over-current protection (manual or automatic reset).
12. Active current limit/torque limit protection.
13. Semiconductor fault protection.
14. Short-circuit/ground fault protection.
15. Serial communication fault protection.
16. Microprocessor fault.
17. Surge protection for transient over-voltage (6,000V, 80 J surge, tested per IEEE C62.41).
18. Visual display of specific fault conditions.

F. Operational Features:

1. System Operation:
    a. When in HAND mode, drive output frequency shall be normally controlled either by increase or decrease pushbuttons on drive keypad.
    b. When in AUTO mode, drive output frequency shall be controlled by a 0V dc to 10V dc signal, 4 mA to 20 mA signal, or faster/slower floating point contacts, or preset speed.
    c. PID set point may be changed with keypad, from a remote 0V dc to 10V dc signal, or 4 mA to 20 mA signal.

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2. Manufacturer's standard features, unless otherwise indicated:
    a. Sustained power loss.
    b. Momentary power loss.
    c. Power interruption.
    d. Power loss ride through of 2 seconds.
    e. Start on the fly.
    f. Stall protection.
    g. Slip compensation.
    h. Automatic restart after power return (ability to enable/disable function).
    i. Critical frequency lockout (three selectable points minimum, by 1.5 Hz steps in 10 Hz bands, to prevent resonance of system).
3. AFD maintenance system software for complete programming and diagnostics.
4. Operate with no motor connected to output terminals.
5. Carrier frequency:
    a. Minimum of six settings to allow adjustment in field.
    b. At or above 5 kHz without derating to satisfy conditions for current, voltage, and horsepower.
6. Factory settings for all parameters, and capability for those settings to be reset.
7. Capability to adjust the following functions, while AFD is running:
    a. Forward/Reverse direction.
    b. Acceleration adjustment from 0 second to 3,600 seconds.
    c. Deceleration adjustment from 0 second to 3,600 seconds.
    d. Minimum of six different preset speeds.
8. Analog output gain to calibrate signal for the application used.

G. Diagnostics:

1. Comprehensive for drive adjustment and troubleshooting.
2. Visual display of specific fault condition.
3. Memory Battery Backup: 100 hours, minimum, during a power loss.
4. Status messages will not stop drive from running, but will prevent it from starting.
5. Fault Condition Messages and History: First fault protection function to be activated, ability to store six successive fault occurrences in order.
6. Minimum Faults Numerically:
    a. Over-current (time and instantaneous).
    b. Over-voltage.
    c. Under-voltage (dc and ac).
    d. Over-temperature (drive, motor windings, motor bearing, pump/fan bearing).
    e. Serial communication fault.
    f. Short-circuit/ground fault (motor and drive).

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g. Motor stalled.
h. Semiconductor fault.
i. Microprocessor fault.
j. Single-phase voltage condition.

H. Operator Interface:

1. AFD shall include a front mounted, sealed keypad, with an English language illuminated LCD display.
2. Keypad shall provide complete programming, operating, monitoring, and diagnostic capability.
3. Keys provided shall include commands for RUN, STOP, and RESET.
4. Provide local-remote pushbutton to conveniently switch between "local" and "remote " modes.
5. AFD display shall provide readouts of output frequency in hertz, output voltage in volts, output current in amps, output power in kilowatts, dc bus voltage in volts, interface terminal status, and fault codes.
6. Displays shall be viewed in easy-to-read illuminated LCD with English language as standard.

I. Additional Features: Provide as follows:

1. **[C: Current Limiting Input Fusing: Fast-acting semiconductor fuses for protection of AFD semiconductor devices.]**
2. Manual Bypass:
   a. Drive and bypass components mounted inside a common enclosure, same NEMA 250 Type as specified for drive enclosure, fully pre-wired, and ready for installation as a single UL Listed device.
   b. Input, output, and bypass contactors, to disconnect power to AFD when motor is running in bypass mode.
   c. 115V ac control transformer, with fused primary.
   d. Thermal overload relay, to protect motor while operating in bypass mode.
   e. Circuit breaker/disconnect switch with "through-the-door" handle mechanism.
   f. Control and safety circuit terminal strip.
   g. "DRIVE/OFF/BYPASS" selector switch.
   h. Pilot lights for "POWER ON" and "FAULT".
   i. "NORMAL/TEST" selector switch, to allow testing and adjustment of AFD while motor is running in bypass mode.
   j. "HAND/OFF/AUTO" selector switch, to provide convenient switching between "hand" and "auto" modes.
   k. Automatic Bypass Relay: Auto transfer to bypass upon drive fault to automatically transfer to line power, and continue motor operation, in event of AFD failure.

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3. V/I Output Converter Module: Provide AFD with two analog current outputs, 4 mA to 20 mA.

2.05 ACCESSORIES

A. Equipment Identification Plates: Furnish 16-gauge Type 316 stainless steel identification plate securely mounted on each separate equipment component in a readily visible location. Plate shall bear 3/8-inch high engraved block type black enamel filled equipment identification number and letters indicated in this Specification.

B. Lifting Lugs: Furnish suitably attached for equipment assemblies and components weighing over 100 pounds.

2.06 SOURCE QUALITY CONTROL

A. Conduct in-circuit testing of printed circuit boards to ensure proper mounting and correct value of all components.

B. Final printed circuit board assemblies shall be functionally tested via computerized test equipment. Tests and acceptance criteria shall be preprogrammed. Test results shall be stored as detailed quality assurance data.

C. Functionally test fully assembled controls with fully loaded induction motors.

D. Inspect and production test, under load, each completed AFD assembly.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer’s printed instructions.

3.02 FIELD QUALITY CONTROL

A. Functional Test:

1. Conduct on each AFD.
2. Inspect AFD for electrical supply termination connections, interconnections, proper installation, and quiet operation.

B. Performance Test:

1. Conduct on each AFD.
2. Perform under actual or approved simulated operating conditions.
3. Test for continuous 8-hour period without malfunction.

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4. Demonstrate performance by operating during the continuous period while varying the application load, as the input conditions allow, to verify system performance.
5. Record test data for report.
6. With plant load connected to normal utility source and AFD running at full load, measure total current harmonic distortion (up to and including 35th harmonic) at location identified in Article Quality Assurance, Paragraph, Harmonics Mitigation.

C. Test Equipment:

1. Use Dranetz, Model No. 626-PA, harmonic distortion monitor and Series 626 disturbance analyzer or equivalent instrument to document results.
2. Provide diagnostic plug-in test card complete with instructions, multiposition selector switch, and meters or built-in diagnostic control panel or ROM-based processor for monitoring ac, dc, and digital signals to assist in troubleshooting and startup of drive.

3.03 MANUFACTURERS' SERVICES

A. Provide manufacturer's representative at Site in accordance with Section 01 43 33, Manufacturers' Field Services, for installation assistance, inspection and Certification of Proper Installation, equipment testing, startup assistance, and training of Owner's personnel for specified component, subsystem, equipment, or system.

END OF SECTION

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SECTION 23 05 93
TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Air Moving and Conditioning Association, Inc. (AMCA): 203, Field Performance Measurement of Fan Systems.
2. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE): HVAC Applications Handbook.
3. Associated Air Balance Council (AABC): National Standards for Field Management and Instrumentation Total System Balance.
4. National Environmental Balancing Bureau (NEBB):
   a. Procedural Standards for Testing, Adjusting, Balancing of Environmental Systems.
   b. Procedural Standards for Measuring Sound and Vibration.
5. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA): HVAC Testing, Adjusting, and Balancing Manual.

1.02 SUBMITTALS

A. Informational Submittals:

1. Documentation of experience record of testing authority.
2. Documentation of current AABC or NEBB certifications for those technicians in responsible charge of the work under this Contract.
3. Submit detailed test and balance procedures, including test conditions for systems to be tested, prior to beginning the Work.
4. Written verification of calibration of testing and balancing equipment.
5. Balancing Log Report following completion of system adjustments including test results, adjustments, and rebalancing procedures.

1.03 QUALITY ASSURANCE

A. Air Balancing and Test Agency Qualifications:

1. Certification by AABC of NEBB for testing, adjusting and balancing of HVAC systems.
2. Corporately and financially independent organization functioning as an unbiased testing authority.
3. Professionally independent of manufacturers, suppliers, and installers of HVAC equipment being tested.
4. Have a proven record of at least five similar projects.

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5. Employer of engineers and technicians regularly engaged in testing, adjusting and balancing of HVAC equipment and systems.

PART 2 PRODUCTS

2.01 MATERIALS

A. Provide materials, tools, test equipment, computers and instrumentation required to complete the work included.

B. Test Hole Plugs: Plug test holes in ducts with plugs made for that purpose and replace any insulation removed to specified conditions.

C. Drives for Belt-Driven Fans:

1. Furnish cast iron or flanged steel sheaves.
2. Sheaves and belt combination shall be capable of providing 150 percent of motor horsepower.

PART 3 EXECUTION

3.01 GENERAL

A. Adjust and balance air and water systems in accordance with standard procedures and recognized practices of the AABC or SMACNA.
B. Adjust and balance the following systems:
1. Supply, return and exhaust air systems.

3.02 ADJUSTING AND BALANCING AIR SIDE

A. Preparation:

1. Prior to beginning the Work, perform the following activities:
a. Review shop drawings and installed system for adequate and accessible balancing devices and test points.
b. Recommend to Engineer dampers that need to be added or replaced in order to obtain proper air control.
c. Verify proper startup procedures have been completed on the system.
d. Verify controls installation is complete and system is in stable operation under automatic control.
e. Verify test instruments have been calibrated to a recognized standard and are within manufacturer’s recommended calibration interval before beginning the Work.

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B. General:

1. When adjustments are made to a portion of a fan system, reread other portions of that same system to determine effects imposed by adjustments. Readjust as necessary.
2. Lock and mark final positions of balancing dampers with permanent felt pen.
3. Correct fan and airflow measurements for Site elevation.

C. Equipment Data:

1. Collect the following data and included in final report:
    a. Type of unit.
    b. Equipment identification number.
    c. Equipment nameplate data (including manufacturer, model, size, type, and serial number).
    d. Motor data (frame, hp, volts, FLA rpm, and service factor).
    e. Sheave manufacturer, size, and bore.
    f. Belt size and number.
    g. Sheave centerline distance and adjustment limits.
    h. Starter and motor overload protection data.
    i. Include changes made during course of system balancing.

D. Fan Systems:

1. Measure fan system performance in accordance with AMCA 203.
2. In each system at least one airpath from fan to final branch duct termination shall have dampers fully open. Achieve final air quantities by adjusting fan speed.
3. Adjust Fan Air Volumes:
    a. Adjust fan speeds and motor drives for required equipment air volumes, with allowable variation of plus 10 percent minus 0 percent.
    b. After final adjustments, do not operate motor above nameplate amperage on any phase.
    c. After final adjustments, do not operate fan above maximum rated speed.
    d. Perform airflow test readings under simulated or actual conditions of full cooling, full heating, minimum outside air, full outside air and exhaust, and full return air.
    e. Provide and make drive and belt changes on motors or fans as required to adjust equipment to specified conditions. Drives shall be able to deliver 150 percent of motor horsepower. Provide written notice to air handling unit manufacturer and Owner and Engineer if drive or belt changes were made.

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4. Adjust outside air dampers, return air dampers, relief air dampers, exhaust air dampers, and motorized louvers for maximum and minimum air requirements.
5. Read and record static pressures at unit inlet and discharge, each filter set, coils, dampers, plenums, and mixing dual-duct or adjustable-volume boxes, on every supply, return, and exhaust fan for each test condition.
6. Read and record motor amperage on all phases for each test condition.

E. Air Terminal Devices:

1. Terminal Airflow Calibration: Calibrate and set the flow coefficients in terminal controller units to ensure controller readings are identical to measured values. This shall be a one-point calibration at maximum flow conditions. Record coefficient values.
2. Test each terminal flow device at minimum and maximum flow conditions. Ensure terminal controller is under control at time of each test.
3. If airflow of terminal device is derived from two or more flow streams, the individual air streams shall be measured and recorded independently for each test.
4. In each terminal system at least one airpath from terminal to final duct termination shall have dampers fully open.
5. Adjust air volumes on each terminal to quantity shown, with allowable variation of plus 10 percent minus 5 percent.

F. Air Outlets and Inlets:

1. In each system at least one air path from fan to final branch duct termination shall have dampers fully open.
2. Adjust air volumes on supply diffusers and grilles, and on return and exhaust grilles, to the quantity shown, with allowable variation of plus or minus 10 percent.
3. Adjust diffusers and grilles for proper deflection, throw, and coverage. Eliminate drafts and noise where possible.
4. After final adjustments are made secure dampers to prevent movement and mark final positions with permanent felt pen.

G. Building Static Pressure:

1. Measure building static pressure relative to outside in perimeter entrances during normal system conditions that would yield widest range in internal building pressure.
2. Adjust building static pressure control parameters to ensure perimeter entrances are positive to outdoors by 0.05-inch WC with entrance doors closed.

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3. For multi-story buildings, test pressure conditions at ground, intermediate, and upper levels.

3.03 FIELD QUALITY CONTROL

A. General: Perform functional tests as required by Section 01 91 14, Equipment Testing and Facility Startup.

B. Performance Testing:

1. Electric Heating Coil Testing:
   a. Adjust system as required to achieve full output from coil.
   b. Read and record amperages and voltages for all phases.
2. Vibration Testing:
   a. Upon completion of air system balance, perform vibration testing as specified below for the following rotating or reciprocating equipment:
   b. Test Procedures:
      1) Identify maximum vibration velocity limits as specified for each piece of equipment to be tested.
      2) Take measurements at each bearing housing using calibrated electronic analyzer.
      3) Measure velocity in direction parallel to rotating shaft, and in two directions perpendicular to shaft and to each other. Align measurement directions where possible to the horizontal and vertical planes.
      4) Record log shall include equipment symbol or tag, location, identification, specified vibration velocity limits, and maximum measured velocity in each direction.
      5) Notify Engineer if amplitude exceeds upper limit specified.

C. Balancing Log Report Requirements:

1. Include narrative description for each system explaining TAB methodology and assumptions used. Clearly identify test conditions for tests performed. Include control setpoint.
2. Log and record operational information from every test for each system, as necessary to accomplish services described.
3. Include equipment data for units tested.
4. Include reduced set of HVAC Drawings or system schematic diagrams with each element uniquely identified and indexed to balance log.
5. Indicate recorded site values, and velocity and mass correction factors used to provide equivalent standard air quantities.
6. Include separate section in log, if necessary, describing operating difficulties in air or water systems that could not be eliminated by specified procedures. Identify these problems by system and location

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within building; include outline or summary of condition and its effect on building, and describe corrective actions attempted and recommended.

D. Quality Control Verification:

1. After adjustments have been completed and balance logs submitted, balancing and testing agency shall be available to demonstrate the following:
   a. Air and water balancing procedures, vibration tests, and verification of test results.
   b. Perform spot tests on a maximum of 20 percent of total diffusers and grilles, on two air handling fan devices per building with measuring equipment used in original tests, at random points selected by Engineer.
   c. Results of these spot tests shall agree with balance logs within plus or minus 10 percent. Where this accuracy cannot be verified, rebalance portions of system as requested by Engineer.
   d. At completion of rebalance procedures, perform another spot test if required to verify results.

END OF SECTION

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SECTION 23 07 00
HVAC INSULATION

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Society of Heating, Refrigerating & Air-Conditioning Engineers Inc. (ASHRAE): 90.1, Energy Standard for Buildings Except Low-Rise Residential Buildings.
2. ASTM International (ASTM):
    a. B209, Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
    b. C547, Standard Specification for Mineral Fiber Pipe Insulation.
    c. C553, Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications.
    d. C1071, Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material).
    e. C1139, Standard Specification for Fibrous Glass Thermal Insulation for Sound Absorbing Blanket and Board for Military Applications.
    f. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
    g. G21, Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi.
    h. G22, Standard Practice for Determining Resistance of Plastics to Bacteria.
3. Association of the Nonwoven Fabric Industry (INDA). IST 80.6, Water Resistance (Hydrostatic Pressure).
4. National Fire Protection Association (NFPA):
    a. 90A, Standard for the Installation of Air Conditioning and Ventilating Systems.
    b. 255, Standard Method of Test of Surface Burning Characteristics of Building Materials.
    c. 259, Standard Test Method for Potential Heat of Building Materials.
5. Underwriters' Laboratories, Inc. (UL).

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1.02 DEFINITIONS

A. Cold Air Ductwork: Designed to convey mechanically cooled air or return ducts in such systems.

B. Warm Air Ductwork: Designed to convey mechanically heated air or return ducts in such systems.

1.03 SUBMITTALS

A. Action Submittals: Product description, list of materials and thickness for each service or equipment scheduled, locations, and manufacturer's installation instructions.

B. Informational Submittals:

1. Proof of compliance for test of products for fire rating, corrosiveness, and compressive strength.
2. Operation and Maintenance Data as specified in Section 01 78 23, Operation and Maintenance Data.

1.04 QUALITY ASSURANCE

A. Materials furnished under this Specification shall be standard, cataloged products, new and commercially available, suitable for service requiring high performance and reliability with low maintenance, and free from all defects.

B. Provide materials by firms engaged in the manufacture of insulation products of the types and characteristics specified herein, whose products have been in use for not less than 5 years.

C. UL listing or satisfactory certified test report from an approved testing laboratory is required to indicate fire hazard ratings for materials proposed for use do not exceed those specified.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Manufacturer's Stamp or Label:

1. Every package or standard container of insulation, jackets, cements, adhesives and coatings delivered to Project Site for use must have manufacturer's stamp or label attached, giving name of manufacturer, brand, and description of material.
2. Insulation packages and containers shall be marked "asbestos-free."

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PART 2 PRODUCTS

2.01 GENERAL

A. Insulation exterior shall be cleanable, grease-resistant, nonflaking, and nonpeeling.

B. Insulation shall conform to referenced publications and specified temperature ranges and densities in pounds per cubic foot.

C. Insulation for fittings, flanges, and valves shall be premolded, precut, or job-fabricated insulation of same thickness and conductivity as used on adjacent piping.

D. Fire Resistance:

1. Insulation, adhesives, vapor barrier materials and other accessories, except as specified herein, shall be noncombustible.
2. Use no fugitive or corrosive treatments to impart flame resistance.
3. Flame proofing treatments subject to deterioration resulting from the effects of moisture or high humidity are not acceptable.
4. Materials including facings, mastics, and adhesives, shall have fire hazard rating not to exceed 25 for flame spread without evidence of continued progressive combustion, and 50 for smoke, developed as per tests conducted in accordance with ASTM E84 (NFPA 255) methods.

E. Materials exempt from fire-resistant rating:

1. Nylon anchors.
2. Treated wood inserts.

F. Materials exempt from fire-resistant rating when installed in outside locations, buried, or encased in concrete:

1. Polyurethane insulation.
2. PVC casing.
3. Fiberglass-reinforced plastic casing.

2.02 DUCT INSULATION

A. Type D1—Blanket (ASTM C553, Type 1, Class B3):

1. Fiberglass, nominal 1 pcf density blanket, K factor 0.31 maximum at 75 degrees F mean, with factory-applied FSK (foil-scrim-kraft) vapor barrier jacket, for temperatures to 250 degrees F.

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2. Manufacturers and Products:
    a. CertainTeed; Duct Wrap.
    b. Johns Manville; Microlite.
    c. Owens/Corning Fiberglass; Soft R.
    d. Knauf; Ductwrap.

B. Type D2—Board:

1. Fiberglass, minimum 2.75 pcf density board, K factor 0.23 maximum at 75 degrees F mean, with factory-applied FSK (foil-scrim-kraft) vapor barrier jacket, for temperatures from 0 degree F to 450 degrees F.
2. Manufacturers and Products:
    a. CertainTeed; CertaPro Commercial Board.
    b. Knauf; Duct Slab.
    c. Owens/Corning Fiberglass; TIW.
    d. Johns Manville; Ductboard.

C. Type D3—Liner (ASTM C1071, Type 1):

1. Fiberglass, nominal 1.5 pcf density liner, K factor 0.25 maximum at 75 degrees F mean, black composite coated surface exposed to airstream to prevent erosion of glass fibers, for temperatures to 250 degrees F.
2. Liquid water repellency rating not less than 4 when tested in accordance with INDA IST 80.6.
3. Potential heat value not exceeding 3,500 Btu/lb when tested in accordance with NFPA 259 and meeting the classification of “Limited Combustible” as defined by NFPA 90A.
4. Maximum rated velocity not less than 6,000 fpm when tested in accordance with ASTM C1071.
5. Resistant to microbial growth using a “no growth criteria” when tested in accordance with ASTM C1139, ASTM G21, and ASTM G22.
6. Manufacturers and Products:
    a. CertainTeed; Toughgard.
    b. Johns Manville; Linacoustic (rectangular), Spinacoustic (Round).
    c. Knauf; Acoustic Duct Liner.

D. Type D5—Flexible Elastomeric (ASTM 534, Type I for tubular materials and Type II for sheet materials):

1. Closed-cell, sponge- or expanded-rubber materials.
2. Manufacturers and Products:
    a. Aeroflex USA Inc.; Aerocel.
    b. Armacell LLC; AP Armaflex.
    c. RBX Corporation; Insul-Sheet 1800 and Insul-Tube 180.

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2.03 INSULATION FINISH SYSTEMS

A. Type F1—PVC:

1. Polyvinyl chloride (PVC) jacketing, white, for straight run piping and fitting locations, temperatures to 159 degrees F.
2. Manufacturers and Products:
   a. Johns Manville; Zeston.
   b. Ceel-Co; 550.

B. Type F2—Paint:

1. Acrylic latex paint, white, and suitable for outdoor use.
2. Manufacturers and Products:
   a. Armstrong; WB Armaflex finish.
   b. Rubatex; 374, white finish.

C. Type F3—Aluminum:

1. Aluminum Roll Jacketing: For straight run piping, wrought aluminum Alloy 3003, 5005, 1100 or 3105 to ASTM B209 with H-14 temper, minimum 0.016-inch thickness, with smooth mill finish.
2. Moisture Barrier: Provide factory applied moisture barrier, consisting of 40-pound kraft paper with 1-mil-thick low-density polyethylene film, heat and pressure bonded to inner surface of the aluminum jacketing.
3. Fitting Covers: Material as for aluminum roll jacketing, premolded, one or two piece covers, which includes elbows, tee/valves, end caps, mechanical line couplings, specialty fittings, etc.
4. Manufacturer and Product: RPR Products; INSUL-MATE.

PART 3 EXECUTION

3.01 APPLICATION OF PIPING INSULATION

A. Install insulation products in accordance with manufacturer’s written instructions, and in accordance with recognized industry practices.

B. Apply insulation over clean, finish painted, and dry surfaces.

C. Use insulating cements, lagging adhesives, and weatherproof mastics recommended by insulation manufacturer.

D. Install insulation materials with smooth and even surfaces. Insulate each continuous run of piping with full-length units of insulation, with a single cut piece to complete the run. Do not use cut pieces of scraps abutting each other.

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E. Butt insulation joints firmly together to ensure a complete and tight fit over surfaces to be covered.

F. Maintain integrity of vapor-barrier jackets on pipe insulation, and protect to prevent puncture or other damage. Seal open ends of insulation with mastic. Sectionally seal all butt ends of chilled water and condensate drain piping insulation at fittings with white vapor barrier coating.

G. Cover valves, flanges, fittings, and similar items in each piping system with equivalent thickness and composition of insulation as applied to adjoining pipe run. Install factory molded, precut or job-fabricated units. Finish cold pipe fittings with white vapor barrier coating and hot piping with white vinyl acrylic mastic, both reinforced with glass cloth.

H. Install protective metal shields and foamglass inserts where pipe hangers bear on outside of insulation.

I. Insulation on piping that is to be heat traced shall be installed after installation of heat tape.

J. Insulate valve bodies, flanges, and pipe couplings.

K. Insulate and vapor seal hangers, supports, anchors, and other piping appurtenances that are secured directly to cold surfaces.

L. Do not allow insulation to cover nameplates or code inspection stamps.

M. Install removable insulation sections on devices that require access for maintenance of equipment or removal, such as unions and strainer end plates.

N. Connection to Existing Piping: Cut back existing insulation to remove portion damaged by piping revisions. Install new insulation.

O. Cold Surfaces: Provide continuous vapor seal on insulation on cold surfaces where vapor barrier jackets are used.

P. Placement:

1. Slip insulation on pipe or tubing before assembly, when practical, to avoid longitudinal seams.
2. Insulate valves and fittings with sleeved or cut pieces of same material.
3. Seal and tape joints.

Q. Insulation at Hangers and Supports: Install under piping, centered at each hanger or support.

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R. Vapor Barrier:

1. Provide continuous vapor barrier at joints between rigid insulation and pipe insulation.
2. Install vapor barrier jackets with pipe hangers and supports outside jacket.
3. Do not use staples and screws to secure vapor sealed system components.

3.02 INSTALLATION OF DUCTWORK INSULATION

A. General: Install insulation products in accordance with the manufacturer's written instructions and in accordance with recognized industry practices.

B. Install insulation materials with smooth and even surfaces.

C. Clean and dry ductwork prior to insulation. Butt insulation joints firmly together to ensure complete and tight fit over surfaces to be covered.

D. Maintain integrity of vapor-barrier on ductwork insulation and protect it to prevent puncture and other damage. Tape all punctures.

E. Seal longitudinal and circumferential joints with FSK tape, and finish with fiberglass mesh fabric embedded in vapor barrier mastic.

F. Extend ductwork insulation without interruption through walls, floors, and similar ductwork penetrations, except where otherwise indicated.

G. Except as otherwise indicated, omit insulation on ductwork where internal insulation or sound absorbing linings have been installed.

H. Refer to Section 23 31 13, Metal Ducts and Accessories, for installation of internal duct liner.

3.03 INSTALLATION OF EQUIPMENT INSULATION

A. Application Requirements: Insulate where external surface temperature of equipment is below ambient temperature in the space, including surfaces that have a recognized possibility for condensation.

B. Install equipment thermal insulation products in accordance with manufacturer's written instructions and in compliance with recognized industry practices to ensure that insulation serves intended purpose.

C. Install insulation materials with smooth and even surfaces and on clear and dry surfaces. Redo poorly fitted joints. Do not use mastic or joint sealer as filler for gaping joints and excessive voids resulting from poor workmanship.

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D. Maintain integrity of vapor-barrier on equipment insulation and protect it to prevent puncture and other damage.

E. Provide removable insulation sections to cover parts of equipment that must be opened periodically for maintenance; include metal vessel covers, fasteners, flanges, frames, and accessories.

F. Replace damaged insulation that cannot be repaired satisfactorily, including units with vapor barrier damage and moisture-saturated units.

G. Avoid using scrap pieces of insulation where larger sheets will fit.

3.04 INSTALLATION OF INSULATION FINISH SYSTEMS

A. Use a continuous friction type joint to hold jacket in-place, providing positive weatherproof seal over entire length of jacket.

B. Secure circumferential joints with preformed snap straps containing weatherproof sealant.

C. On exterior piping, apply coating over insulation and vapor barrier to prevent damage when aluminum fitting covers are installed.

D. Do not use screws or rivets to fasten the fitting covers.

E. Install removable prefabricated aluminum covers on exterior flanges and unions.

F. Caulk and seal all exterior joints to make watertight.

3.05 PIPING INSULATION REQUIREMENTS

A. Refrigeration Suction:

1. Type P3, elastomeric. (See Section 22 07 00, Plumbing Piping Insulation)
2. 1/2-inch thickness for pipe sizes up to 1 inch.
3. 3/4-inch thickness for pipe sizes over 1 inch.

B. Condensate Drain:

1. Type P3, elastomeric. (See Section 22 07 00, Piping Plumbing Insulation)
2. 1/2-inch thickness for pipe sizes up to 2-5/8 inches ID.
3. 3/4-inch thickness for pipe sizes over 2-5/8 inches ID.

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3.06 DUCTWORK INSULATION REQUIREMENTS

A. Mechanically Cooled and Heated Supply and Return Air; (Concealed):

1. Type D1, blanket.
2. 2-inch thickness.

B. Mechanically Cooled and Heated Supply and Return Air, and Outside Air (Exposed to View):

1. Type D5, board.
2. 1-1/2-inch thickness.

C. Mechanically Cooled and Heated Supply and Return Air; (Within 30 Feet of Air Handling Unit):

1. Type D3, liner.
2. 1-1/2-inch thickness.

D. Mechanically Cooled and Heated Supply Air, Return Air, and Outside Air (outdoors):

1. Type D3, liner.
2. 2-inch thickness.

E. Outside Air Intake:

1. Type D1, blanket.
2. 1-1/2-inch thickness.

F. Transfer Air:

1. Type D3, liner.
2. 1/2-inch thickness.

G. Air Distribution Devices: Refer to Section 23 37 00, Air Outlets and Inlets, for requirements.

3.07 INSULATION FINISH REQUIREMENTS

A. Piping, Duct, and Equipment Insulation (Concealed Areas): Factory finish.

B. Ductwork Insulation (Exposed to View, Indoors): Factory finish.

C. Piping Insulation (Outdoors): Type F3, aluminum.

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D. Ductwork Insulation (Outdoors): Double Wall Duct, D2 Insulation between ductwork.

E. Apply coating of insulating cement where needed to obtain smooth and continuous appearance.

3.08 FIELD QUALITY CONTROL

A. Test factory-applied materials assembled. Field-applied materials may be tested individually.

END OF SECTION

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SECTION 23 09 00
INSTRUMENTATION AND CONTROL DEVICES FOR HVAC

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American National Standards Institute (ANSI): INCITS 4, Information Systems - Coded Character Sets - 7-Bit American National Standard Code for Information Interchange (7-Bit ASCII).
2. American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE):
   a. Handbook Fundamentals.
   b. Guideline 3, Reducing Emission of Fully Halogenated Refrigerants in Refrigeration and Air-Conditioning Equipment and Systems.
   c. 135, Data Communication Protocol for Building Automation and Control Networks.
3. American Society of Mechanical Engineers (ASME): B19.3, Safety Standard for Compressors for Process Industries.
4. American Water Works Association (AWWA): C704, Propeller-Type Meters for Waterworks Applications.
5. Electronic Industries Alliance (EIA):
   a. TIA-232-F, Interface Between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange.
   b. 485, Standard for Electrical Characteristics of Generators and Receivers for Use in Balanced Digital Multi-point Systems.
6. Federal Communications Commission (FCC).
7. International Organization for Standardization (ISO): 8802-3, Information Technology - Telecommunication and Information Exchange Between Systems - Local and Metropolitan Area Networks - Specific Requirements - Carrier Sense Multiple Access with Detection (CSMA/CD) Access Method and Physical Layer Specifications.
8. National Electrical Manufacturers' Association (NEMA): 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
9. National Fire Protection Association (NFPA):
   a. 70, National Electrical Code.
   b. 90A, Standard for the Installation of Air Conditioning and Ventilating Systems.
10. Underwriters Laboratories, Inc. (UL): 916, Standard for Safety Energy Management Equipment.

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1.02 DEFINITIONS

A. The terms “HVAC Control System,” “Automatic Temperature Control System,” “Building Automation System,” and “Environmental Management and Control System” shall be considered equivalent and used interchangeably for the purposes of this Contract.

B. Algorithm: A software procedure for solving a recurrent mathematical or logical problem.

C. Analog: A continuously varying signal or value (temperature, current, velocity, etc.).

D. Binary: A two-state system where an “ON” condition is represented by a high signal level and an “OFF” condition is represented by a low signal level.

E. Control Wiring:

1. Wiring, high or low voltage other than power wiring required for proper operation of mechanical systems.
2. Includes conduit, wire and wiring devices to install complete control system including motor control circuits, interlocks, thermostats, PE and EP switches and like devices.
3. Includes wiring from DDC cabinet to all sensors and points defined in the Points List summary or specified herein and required to execute sequence of operation.
4. Includes necessary power wiring to HVAC control devices, digital controllers including terminal units and actuators.

F. Control Process: Software required to complete control loop from input signal to interlock logic and process calculation to final output signal control.

G. Deadband: Temperature range over which no heating or cooling energy is supplied, such as 72 degrees F to 78 degrees F; as opposed to single point changeover or overlap, or a range from set point over which no control action is taken.

H. Direct Digital Control (DDC): Consists of microprocessor-based controllers with control logic performed by software. Analog-to-digital (A/D) converters transform analog values into digital signals that microprocessor can use.

I. Power Wiring: Line voltage wiring to mechanical equipment. Line voltage wiring that also serves as control circuit, such as line voltage thermostat or involves interlocking with damper shall be considered control wiring.

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J. Abbreviations that may be used in this section:

1. AC: Air Conditioning.
2. ATC: Automatic Temperature Control.
3. BAS: Building Automation System.
4. CHWS/R: Chilled/Hot Water Supply/Return.
5. CMOS: Complementary Metal Oxide Semiconductor.
6. DDC: Direct Digital Control.
7. DX: Direct Expansion.
8. EP: Electro-Pneumatic
9. EEPROM: Electronic Erasable Programmable Read Only Memory.
10. EMCS: Environmental Management and Control System.
11. HCP: HVAC Control Panel.
12. HGS/R: Hot Glycol Supply/Return.
13. HMI: Human-Machine Interface.
14. HOA: Hand-Off-Auto (Switch).
15. HVAC: Heating, Ventilation, and Air Conditioning.
16. IP: Current (I) - Pressure (P), as in IP transducer.
17. LCD: Liquid Crystal Display.
18. LED: Light Emitting Diode.
19. PE: Pneumatic-Electric
20. PLC: Programmable Logic Controller.
21. RAM: Random Access Memory.
22. RTD: Resistance Temperature Detectors.
23. VAV: Variable Air Volume.
24. W3: Nonpotable Water.

1.03 SYSTEM DESCRIPTION

A. General Requirements:

1. Provide control wiring, power wiring, conduit, hardware, and electrical work associated with the HVAC control system.
2. Provide control wiring between HVAC control panel contacts and field control devices, such as duct smoke detectors and motor starter control coil contacts.
3. Provide controls necessary for entire system to have fail-safe operation.
4. Control sequences and functions including alarms, monitoring and resetting functions, and operational sequences shall not be limited to point schedules and sequences of operation.
5. Provide sequences and functions as required to deliver a fully functioning HVAC system.

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B. Control System Types:

1. The following control system types may be used in this Project:
   a. Electric/Electronic Control System (ELECTRIC):
      1) System using simple electric or electronic control devices.
      2) User interface at control device.
   b. Networked DDC Control System (NETWORKED DDC):
      1) Microprocessor-based DDC Control System utilizing standalone DDC controllers.
      2) Information within control system can be utilized by any control component over high-speed network.
      3) User interface via computer workstation and/or portable terminal.
      4) Refer to Section 23 09 23, Direct-Digital Control System for HVAC, for additional requirements.
2. Provide control system(s) of architecture defined in Control Type Schedule, below:

Control Type Schedule

Location	System	Control Type
SINGLE ROOM SPLIT SYSTEM UNITS	Where operating sequences call for simple thermostatic or interlock control	ELECTRIC
Process Areas	All	NETWORKED DDC
Office Building	All	NETWORKED DDC

C. Performance Requirements: Design control system and equipment to perform under the following conditions:

1. Temperature, Ambient:
   a. Summer maximum 95.9 DB/59.6 WB degrees F.
   b. Winter minimum 7.8 DB degrees F.
   c. Based on ASHRAE Handbook Fundamentals weather data for the City of Four Corners Regional Airport, Farmington, NM.
2. Temperature, Indoor:
   a. Heated and Air-conditioned Process Areas: Summer maximum 85 degrees F; winter minimum 50 degrees F.
   b. Air-conditioned Nonprocess Areas: Summer maximum 75 degrees F; Winter minimum 70 degrees F.

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c. Areas containing SCADA Equipment; Summer maximum 75 degrees F; Winter minimum 75 degrees F.
d. Laboratory: Summer maximum 72 degrees F; winter minimum 72 degrees F.

D. Refer to Section 01 61 00, Common Product Requirements, for additional environmental performance requirements.

1.04 SUBMITTALS

A. Action Submittals:

1. Complete specifications, descriptive drawings, catalog cuts, and descriptive literature that includes make, model, dimensions, weight of equipment, and electrical schematics, for all control system components.
2. Complete system power, interlock, control, and data transmission wiring diagrams no smaller than 11 inches by 17 inches.
3. Complete drawings and schematics of proposed control system, including panel power requirements.
4. System operating sequences to be programmed, in exact English language.
5. Complete points list.
6. Interfaces with HVAC equipment.
   a. Schematic diagram of each equipment item.
   b. Indicate location of each control item in equipment.
   c. Show equipment manufacturer controls where installed.
7. Panel face layout drawings.
8. Damper actuator sizing calculations, in schedule form.
9. Automatic control valve sizing calculations, in schedule form.

B. Informational Submittals:

1. Table identifying which member of Contractor's team is responsible for furnishing and setting in-place power wiring and control wiring of each item or component of HVAC equipment.
2. Recommended procedures for protection and handling of equipment and materials prior to installation.
3. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements.
4. Manufacturer's Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers' Field Services.
5. **[E: Draft maintenance agreement.]**
6. Confirmation that control system Supplier has received, and coordinated with all approved HVAC equipment submittals.

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7. Experience and qualifications of control system Supplier's proposed representative who will supervise installation, adjustment, and calibration of control systems.
8. Performance test plan and schedule.
9. Test Results:
    a. Functional and performance test documentation.
    b. Component calibration sheets for each instrument and panel component as described in Section 40 90 00, Process Instrumentation and Control Systems.
10. Operation and maintenance data: In accordance with Section 01 78 23, Operation and Maintenance Data. In addition, include the following detailed information:
    a. Operation and maintenance instructions for control system as furnished and installed, including control of associated mechanical and electrical equipment.
    b. Record of system adjustments and calibration methods.
    c. Performance test results.

1.05 QUALITY ASSURANCE

A. Materials, devices, appliances, and equipment used shall be indicated as acceptable by established standards of Underwriters Laboratories, Inc. (UL).

B. Codes and Standards: Meet requirements of applicable standards and codes, except when more detailed or stringent requirements are indicated by Contract Documents, including requirements of this section.

1. Underwriters Laboratories: Products shall be UL 916-PAZX listed.
2. National Electrical Code NFPA 70.
3. Federal Communications Commission Part J.
4. Networked DDC Control Systems shall comply with ASHRAE 135 (BACnet).

C. Qualifications of HVAC Controls System Supplier:

1. Minimum of 15 years' experience in design, installation, and maintenance of fully electronic building automation systems.
2. Minimum of 10 years' experience in design, installation, and maintenance of computer based, direct digital control, facility automation systems.
3. Minimum of 5 years' experience as manufacturer's authorized representative in design, installation, and maintenance of manufacturer's system and products.
4. Capable of furnishing factory-trained technicians, competent to provide instruction, routine maintenance, and emergency service onsite within 4 hours after receipt of request.

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5. Factory trained certified engineering and commissioning staff, and complete offsite training facilities.
6. Necessary facilities to provide Owner with complete maintenance, periodic inspection, and service contract. Refer to Paragraph, Maintenance.

D. FCC Regulation: Electronic equipment shall conform to requirements of FCC Regulation, Part 15, Section 15, Governing Radio Frequency Electromagnetic Interference, and be so labeled.

E. Compatibility:

1. System shall have documented history of compatibility by design for minimum of 15 years. Future compatibility shall be supported for no less than 10 years.
2. Compatibility shall be defined as:
   a. Ability to upgrade existing field panels to current level of technology, and extend new field panels on previously installed network.
   b. Ability for any existing field panel microprocessor to be connected and directly communicate with new field panels without bridges, routers, or protocol converters.

F. Preinstallation Meeting: Prior to installation of Networked DDC system a meeting shall be conducted to discuss available points project to the control room for HVAC monitoring.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Comply with Section 01 61 00, Common Product Requirements.

B. Corrosion Protection:

1. Control panels, enclosures, and other equipment containing electrical or instrumentation and control devices, including spare parts, shall be protected from corrosion through use of corrosion-inhibiting vapor capsules.
2. Prior to shipment, capsules shall be provided within shipping containers and equipment as recommended by capsule manufacturer.
3. During construction period, capsules shall be replaced in accordance with capsule manufacturer’s recommendations.

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1.07 MAINTENANCE

A. **[A: Maintenance Service Agreement:**

1. **Furnish a draft maintenance agreement, prepared and signed by the Controls Supplier, to provide the necessary preventive maintenance to keep the various control systems in proper working condition.**
2. **Fully describe the maintenance work to be performed and estimate cost of the maintenance during the 1-year correction period and the subsequent year.**
3. **This service contract shall include 24-hour emergency service, 7 days per week.]**

1.08 EXTRA MATERIALS

A. Furnish, tag, and box for shipment and storage the following **[A: spare parts,] [B: special tools,] [C: and] [D: materials:]**

Item	Quantity
Replacement relays	One complete set per unit, per voltage designation
Special tools required to maintain or dismantle	One complete set for each different size unit

1. Spare parts shall be available for at least 5 years after Substantial Completion.

B. Tools:

1. For each building, furnish one complete set of special tools recommended by manufacturer for maintenance, dismantling, or repair of each separate type of equipment item.
2. Furnish toolbox for storage of special tools. Identify purpose by means of stainless steel or solid plastic nametag attached to box.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Materials, equipment, and accessories specified shall be products of the following manufacturers, unless indicated otherwise:

1. Allen Bradley.
2. Siemens Building Technologies.

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3. Johnson Controls.
4. The Trane Company.
5. Honeywell.

2.02 MATERIALS

A. General:

1. Products used in this installation shall be new, currently under manufacture, and shall have been applied in similar installations for minimum of 2 years.
2. System shall not be used as test Site for new products, unless explicitly approved by Owner's representative, in writing.

B. Control Components:

1. Control range to obtain specified capacities.
2. Sensitivity to maintain control points close enough to set point for acceptable offset, without cycling equipment more frequently than recommended by manufacturer.
3. Field or computer adjustable to actual set point, ranges. Adjustable to other settings that will provide proper operation of entire control system.

C. Controls Interfacing:

1. Interface controls properly with factory supplied components of mechanical systems. Coordinate special control interfacing requirements.
2. For equipment that requires special interfacing with control system, provide equipment with integral controls or provide accessory devices required for operation of total mechanical system.
3. Coordinate interfaces with electrical work as necessary.
4. Provide electric, electronic, and mechanical devices as required to properly interface with prewired control panels furnished with HVAC equipment and with other mechanical and electrical components.

2.03 LABELING

A. All products, namely electrical materials, devices, appliances, and equipment used, shall be indicated as acceptable by established standards of Underwriters Laboratories, Inc. (UL) and Factory Mutual (FM).

B. Valid label affixed to item shall provide indication of product acceptance by required agencies.

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C. HVAC control panels and control components that consist of multiple components shall bear UL listing mark on unit.

2.04 SERVICE CONDITIONS

A. Refer to Section 01 61 00, Common Product Requirements, Section 26 05 02, Basic Electrical Requirements, and Electrical Drawings for classification of areas as hazardous, corrosive, wet, indoor dry, and dust-tight.

B. Use materials and methods, and enclose devices in NEMA enclosure types suitable for classification indicated, and as required by NFPA 70.

C. Exhaust ductwork shall be considered same classification as area served.

D. Instruments within 3 feet of ducts conveying air from spaces classified as Class I, Division 1 or Division 2 (in accordance with NFPA 70) shall be suitable for same area classification as space exhausted.

2.05 ELECTRICAL COMPONENTS AND ACCESSORIES

A. Electrical components shall be provided in accordance with requirements of Division 26, Electrical.

B. Wiring:

1. In accordance with Section 26 05 05, Conductors, and NFPA 70.
2. Insulation shall be rated 600 volts, minimum.

C. Electrical Raceways: In accordance with Section 26 05 33, Raceway and Boxes, and NFPA 70.

D. Provide surge suppressors on each power connection, meeting applicable requirements of Section 40 90 00, Instrumentation and Control for Process Systems.

2.06 FIELD COMPONENTS AND INSTRUMENTS

A. Refer to HVAC controls detailed specification, Section 23 09 13, HVAC Controls, Field Components, and Instruments.

2.07 MICROELECTRONIC CONTROL COMPONENTS

A. Refer to HVAC controls detailed specification, Section 23 09 23, Direct-Digital Control System for HVAC.

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2.08 ACCESSORIES

A. Corrosion-inhibiting vapor capsules as manufactured by:

1. Northern Instruments; Model Zerust VC.
2. Hoffman; Model A-HCI.

B. Lifting Lugs: Provide suitably attached for equipment assemblies and components weighing over 100 pounds.

C. Equipment Identification Plates:

1. Provide 16-gauge Type 316 stainless steel identification plate securely mounted on each separate equipment component and control panel in a readily visible location. Plate shall bear 3/8 inch high engraved block type black enamel filled equipment identification number and letters indicated in this Specification and as shown.
2. Provide adjacent to the following control devices, and for equipment whose function is not readily apparent.
    a. Night low limit thermostats.
    b. Manual override timers.
    c. START/STOP switches.
    d. Humidistats.
    e. Emergency STOP switches.
    f. Special purpose devices.
    g. HVAC control panels.

D. Anchor Bolts: Type 316 stainless steel, sized by equipment manufacturer, and as specified in Section 05 50 00, Metal Fabrications. Coat in accordance with Section 09 90 00, Painting and Coating.

2.09 EQUIPMENT FINISH

A. Provide materials and equipment with manufacturer’s standard finish system. Provide manufacturer’s standard finish color, except where specific color is indicated.

B. If manufacturer has no standard color, provide gray finish as approved by Owner.

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PART 3 EXECUTION

3.01 SEQUENCES OF OPERATION

A. Reference Contract Drawings.

3.02 INSTALLATION

A. General:

1. Install systems and materials in accordance with manufacturer's instructions, rough-in drawings, and equipment details.
2. Changes in location or installation of control devices or equipment shall be approved by Engineer before proceeding with the Work.
3. Mount devices requiring manual reset and all other user serviceable control devices in readily accessible locations.

B. Hazardous and Corrosive Areas:

1. In the following areas, provide control equipment and wiring suitable for installation in Class 1, Division 2, Group C or Group D hazardous areas:
   a. **[A:]**
   b. **[B:]**
2. In the following areas, control equipment and wiring shall be suitable for continuous exposure to saturated hydrogen sulfide.
   a. **[A:]**
   b. **[B:]**
3. In the following areas, control equipment and wiring shall be suitable for corrosive environments, as follows:
   a. **[A:]**
   b. **[B:]**
4. Protect control equipment located in areas identified as being corrosive as follows:
   a. Use corrosion-inhibiting vapor capsules inside control equipment enclosures and HCP.
   b. Replace capsules prior to Owner's acceptance of equipment.

C. Wiring:

1. General:
   a. Install electric wire, cable, fittings, and conduit associated with systems specified in this section, in accordance with requirements of NFPA 70.
   b. Install control and interlock wiring separate from power wiring.

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c. Number code or color code conductors, excluding those used for individual zone controls, appropriately for future identification and servicing of control system.
d. Provide wire markers on each conductor in panel and at load connections. Identify circuit with control wire number.
e. Restrain wiring in control panels by plastic ties or ducts.
f. Hinge wiring shall be secured at each end so that any bending or twisting will be around longitudinal axis of wire and bend area shall be protected with sleeve.
g. Arrange wiring neatly, cut to length, and remove surplus wiring. Provide abrasion protection for any wire bundles that pass through holes or across edges of sheet metal.
h. Use manufacturer's recommended tool with proper sized anvil for crimp terminations. No more than two wires may be terminated in single crimp lug and no more than two lugs may be installed on single screw terminal.
i. Wiring shall not be spliced or tapped except at device terminals or terminal blocks.
j. Properly support and run wiring in a neat manner.
k. Run wiring parallel or at right angles to building structure.

2. Concealment:
a. Generally conceal wiring from view, except in mechanical rooms and areas where other conduit and piping are exposed; install exposed wiring and conduit to be as unobtrusive as possible.
b. Install line voltage control wiring, wiring exposed to view, surface-mounted wiring, and wiring concealed within walls in conduit, in accordance with Division 26, Electrical.
c. Install exposed and concealed low voltage control wiring systems in conduit.
d. Wiring within enclosures shall be neatly bundled and anchored to prevent obstruction to devices and terminals.
e. Conduit shall be sized to suit the number, type, and size of conductors as specified in Section 26 05 05, Conductors.

D. End-User Accessible Control Components:

1. Do not mark room thermostats.
2. Mount user adjustable control components (room thermostats, humidistats, temperature sensors, humidity sensors, etc.) level and in accordance with applicable accessibility requirements of local Building Code.

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E. Control Valves:

1. Verify correctness of installation.
2. For pneumatic systems, calibrate and adjust positioners and IP transducers.
3. Verify proper control action.
4. Adjust limit switch settings.
5. Adjust opening and closing speeds, and travel stops.
6. Stroke control valves by means of associated controller.

F. Control Dampers:

1. Verify correctness of installation.
2. For pneumatic systems, calibrate and adjust positioners and IP transducers.
3. Verify proper control action.
4. Adjust limit switch settings.
5. Adjust opening and closing speeds, and travel stops.
6. Stroke control dampers by means of associated control output.

G. Adjustable Frequency Drives:

1. Verify control wiring installed to adjustable frequency drive.
2. Calibrate and adjust remote speed control loop and feedback loop.
3. Verify control actions and interlocks.
4. Adjust minimum and maximum speed settings.
5. Ramp adjustable frequency drive by simulation of associated controller output.

H. DDC Controllers:

1. Verify control wiring for correctness.
2. Verify power wiring.
3. Calibrate and adjust manual and auto control actions of controllers.
4. Tune control loop.
5. Stroke associated final element through controller output.
6. Verify set points and alarm functions.

I. HVAC Control Panel (HCP) Equipment:

1. Mount HCPs level, plumb, and securely to wall or column. Verify that adequate clearance is provided to allow for full front panel swing.
2. Provide field terminations and conduit knockouts for control/instrumentation wiring.
3. Field termination wiring shall have designated instrument tag.

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4. Panel cutouts shall be cut, punched, or drilled and smoothly finished with round edges.
5. Provide separate conduit entry for each power feeder circuit.
6. Signals requiring grounding shall be grounded within panel.
7. Field end of conductor shield/drain wires shall be folded back and placed under heat-shrink tubing without being grounded.
8. Panel end of conductor shield/drain wires shall be covered with clear tubing at panel and grounded.
9. Calibrate instrumentation provided on control panels.
10. Provide labels for internal panel material (such as, terminal blocks, power supplies, relays, PLC racks).

3.03 FIELD QUALITY CONTROL

A. Performance and Functional Testing:

1. Tests and certification shall be as specified in Section 01 91 14, Equipment Testing and Facility Startup, and Section 01 43 33, Manufacturers' Field Services.
2. HVAC controls interface with process control system shall be coordinated with the Work of Section 40 90 00, Instrumentation and Control for Process Systems.

3.04 MANUFACTURER'S SERVICES

A. Provide manufacturer's services in conformance with requirements of Section 01 43 33, Manufacturers' Field Services.

3.05 TRAINING

A. Provide training of Owner's personnel to enable them to operate HVAC equipment in available modes, to adjust set points, and to interpret alarm signals.

B. Training sessions shall be prepared in advance, and arranged for clear, effective transfer of information in minimum time.

3.06 ADJUSTING AND CALIBRATING

A. Control system shall be adjusted and calibrated by qualified manufacturer's representative.

B. Calibrate control devices at time of installation to ensure measuring and reading accuracy.

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C. Adjustment Record:

1. Prepare complete record of system adjustments for each control system.
2. Indicate deviations from specified temperatures.
3. Include copy of completed record in each copy of Operation and Maintenance Manual.

3.07 CLEANING AND TOUCHUP PAINTING

A. Touchup scratches, scrapes, or chips in exterior surfaces with finish matching type, color, consistency, and type of surface of original finish.

END OF SECTION

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SECTION 23 09 13
HVAC CONTROLS, FIELD COMPONENTS, AND INSTRUMENTS

PART 1 GENERAL

1.01 GENERAL

A. This section is a supplement to Section 23 09 00, Instrumentation and Control Devices for HVAC.

B. The requirements of this section shall be provided in addition to those listed in Section 23 09 00, Instrumentation and Control Devices for HVAC.

1.02 EXTRA MATERIALS

A. Furnish, tag, and box for shipment and storage the following special tools:

Item	Quantity
Special tools required to maintain or dismantle	One complete set for each different size unit

PART 2 PRODUCTS

2.01 HVAC CONTROL PANELS (HCP)

A. Provide at locations shown on Drawings for convenient operator interface with control system.

B. A single 120-volt, 20-amp feeder shall serve each HCP, unless otherwise indicated.

C. HCP Contents: Set point adjustment dials, gauges, receiver controllers, manual timers, time clocks, microprocessor control modules, electronic indication relays, control switches, transformers, pilot lights, alarm lights, display screens, keypads, and other devices necessary for particular system.

D. HCP Construction:

1. Construct each HCP to NEMA 250 rating as indicated in Schedule below**,** except where indicated otherwise:

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HVAC Control Panel (HCP) NEMA 250 Construction Schedule	
Location	**NEMA 250 Type**
Office Areas	1
Membrane Facility	3R
All other Process Areas	12

2. Metal enclosure to accommodate secure conduit fittings and protect against electrical transients.
3. Hinged front door with locking handle.
4. Flush-mount manual switches, pilot lights, and direct-reading gauges on front panel face.
5. Identify front panel mounted devices and HCP with labeling in accordance with Section 23 09 00, Instrumentation and Control Devices for HVAC.

E. Panel Listing: Panels shall bear UL or ETL listing mark stating “LISTED ENCLOSED INDUSTRIAL CONTROL PANEL.”

F. Control Devices:

1. Mount inside HCP.
2. Prewired internally.
3. Terminate wires leaving HCP at separately numbered terminal strips (one terminal pair per circuit).
4. Furnish individual connectors for every item of mechanical equipment, integral and remote pilot lights, and other devices described for each panel.
5. Refer to Drawings for power and control circuit requirements.
6. Identify wires by color coding or numerical tags at both ends.
7. Wire control devices without splices to the terminal strip.
8. Furnish integral circuit protection for panel mounted control devices.

G. Terminal Blocks:

1. One-piece molded plastic blocks with screw type terminals and barriers rated for 600 volts.
2. Double sided and supplied with removable covers to prevent accidental contact with live circuits.
3. Furnish permanent, legible identification, clearly visible with protective cover removed.
4. Terminate wires at terminal blocks with crimp type, preinsulated, ring-tongue lugs.

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5. Size lugs for terminal block screws and for the number and size of wires terminated.
6. Provide screwdriver access for blade width of a minimum of 3/16 inch or Klein 601 Series screwdrivers. Terminals requiring use of special screwdrivers are not acceptable.

H. Miscellaneous Accessories:

1. Furnish panel as-built electrical wiring diagrams and schematics, secured to inside of panel door, or enclosed in plastic jackets placed inside each panel.
2. Install plastic or stick-on labels on interior control devices to identify them in conjunction with control schematics.

2.02 CONTROL DAMPERS

A. General:

1. Specification applies to control dampers, except those specified to be furnished with equipment.
2. Furnish opposed-blade type for proportional action and parallel-blade type for two-position action, except where indicated otherwise.

B. Standard Duty Control Dampers (M):

1. Frame:
   a. Nominal 5 inches deep, minimum 16-gauge (127 mm by minimum 1.6 mm) roll formed, hat-shaped channel, reinforced at corners. (Structurally equivalent to 13 gauge (2.3 mm) U-channel.)
   b. Material: Galvanized steel.
2. Blades:
   a. Style: Single skin with three longitudinal grooves, minimum.
   b. Orientation: Horizontal or vertical with thrust washers, as indicated on Drawings.
   c. Minimum 14 gauge (2 mm) equivalent thickness.
   d. Material: Galvanized steel.
   e. Width: Nominal 6 inches (152 mm).
3. Bearings: Molded synthetic sleeve, turning in extruded hole in frame.
4. Seals:
   a. Blade Seals: Inflatable PVC-coated fiberglass material and galvanized steel. Mechanically attached to blade edge.
   b. Jamb Seals: Flexible metal compression type.
5. Linkage: Concealed in frame.

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6. Axles:
    a. Minimum 1/2 inch (13 mm) diameter, hex-shaped, mechanically attached to blade.
    b. Material: Plated steel.

    Performance Data: As scheduled in Control Damper Schedule, Article Supplements.
7. Manufacturers and Products:
    a. Ruskin; Model CD-35.
    b. American Warming and Ventilating.
    c. TAMCO.

2.03 CONTROL DAMPER OPERATORS

A. General:

1. Drawings and Control Diagrams indicate only one damper motor for each motorized damper (M).
2. Select actual quantity of motors required to operate each damper in accordance with size of damper provided.
3. Coordinate exact quantity of damper motors with electrical work to ensure that necessary wiring and conduit is provided for installation.
4. Provide operators for motorized dampers and motorized louvers.

B. Electric Damper Operators:

1. Performance: As scheduled on Drawings. 24V, 60-Hz, modulating.
2. Mounting: In airstream.
3. Ample power to overcome friction of damper linkage and air pressure acting on damper blades.
4. Furnished with external adjustable stops to limit stroke.
5. Operators on modulating dampers that are to be sequenced with other control devices shall have full relay type pilot positioner and interconnecting linkage to provide mechanical feedback that will accurately position and control damper.
6. Intake, relief, and exhaust dampers shall close and return dampers shall open on control failure, unless indicated otherwise.
7. Operating Torque:
    a. Provide multiple independent damper sections, each with separate actuator, as needed to provide minimum of 120 percent of operating torque required by damper(s).
    b. Required damper operating torque for actuator sizing calculations shall include friction of damper linkage and 1-inch WC air pressure on damper blades:
        1) Opposed-Blade Dampers: Minimum 5 inch-pounds per square foot of damper area, unless higher values are recommended by damper manufacturer.

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2) Parallel-Blade Dampers: Minimum 7 inch-pounds per square foot of damper area, unless higher values are recommended by damper manufacturer.

8. Manufacturers:
   a. Belimo.
   b. Siemens Building Technologies.
   c. Johnson Controls.
   d. Honeywell.

2.04 ELECTRIC THERMOSTATS (ET)

A. Office Area Room Thermostat (TIT-1):

1. Modulating electric type, except where two-position action is required.
2. Temperature Scale: Furnish 50 to 90 degrees F dial.
3. External adjustments.
4. Adjustable sensitivity.
5. Nonlocking cover.
6. Insulating back, where exterior wall mounting is indicated.

B. Process Area Room Thermostat (TIT-2):

1. Modulating electric type, except where two-position action is required.
2. Temperature Scale: Furnish 50 to 90 degrees F dial.
3. Concealed adjustments.
4. Adjustable sensitivity.
5. Insulating back where exterior wall mounting is indicated.
6. Locking wire protective guard.

C. Insertion and Immersion Thermostats (TIT-3):

1. Modulating type, except where two-position action is required.
2. Adjustable sensitivity and reset functions for stable control.
3. Dial range with concealed adjustment suitable for application.
4. Immersion bulbs mounted in separable wells.
5. Outside air thermostats shielded from sun with remote bulb and compensated capillary.

2.05 ELECTRONIC SENSORS

A. Temperature (TS):

1. General Requirements:
   a. Sensors and transmitters shall be provided, as outlined in input/output summary and sequence of operations.

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b. Temperature sensor shall resistance type, and shall be either two-wire 1,000-ohm nickel RTD or two-wire 1,000-ohm platinum RTD.

c. The following point types (and accuracy of each) are required, and their associated accuracy values include errors associated with sensor, lead wire, and A to D conversion:

Point Type	Accuracy
Room Temperature	± 0.5°F
Duct Temperature	± 0.5°F
All Others	± 0.75°F

2. Room Temperature (TS-1):
   a. Constructed for either surface or wall box mounting.
   b. Nonlocking wire protective guards for room temperature sensors installed in process areas.
   c. Shall have the following options when specified:
      1) Set point reset slide switch providing plus or minus 3 degrees F (adjustable) range.
      2) Individual heating/cooling set point slide switches.
      3) Momentary override request pushbutton for activation of after-hours operation.
      4) Analog thermometer.
3. Duct Temperature (TS-2):
   a. Accuracy: Plus or minus 1 degree F.
   b. Range:
      1) Heating: 40 to 140 degrees F.
      2) Cooling: 30 to 100 degrees F.
   c. Element:
      1) Rigid insertion, 12-inch length, through sealed opening in center of duct.
      2) Averaging, for ducts or plenums with any dimension greater than 36 inches. Sealed opening in duct. Sensing element incorporated in copper capillary a minimum of 20 feet long, serpentined across full area of airflow.

B. Differential Pressure (DP):

1. General:
   a. Temperature compensated.
   b. Vary output voltage with change in differential pressure. Voltage shall vary linearly from 0V dc to 10V dc according to differential pressure between high and low pressure ports.

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c. Sensing range shall be suitable for application with linearity of 1.5 percent of full scale and offset of less than 1 percent of full scale.
d. Capable of withstanding up to 150 percent of rated pressure without damage.
e. Compatible with 14V dc to 30V dc supply voltage range.

2. Duct Air Static Differential Pressure:
   a. MAMAC transmitter.
   b. Dwyer A302 duct probe.
   c. Install static pressure fittings for differential pressure sensors and switches at a right angle to the flow.
3. Space Air Static Differential Pressure: MAMAC transmitter.

C. Position Indicator:

1. 0 to 100 percent open, for damper, inlet vane, or similar.
2. Potentiometer, 0 to 2,000 ohm equals 0 to 100 percent.

D. Relative Humidity (RH):

1. Room Relative Humidity.
2. Accuracy: Plus or minus 2 percent.
3. Range: 10 to 95 percent.
4. Solid state.

E. Current Sensors (CS):

1. Fixed Setpoint, Digital Output Current Switch:
   a. Application: Monitoring status of direct drive equipment.
   b. Current-operated solid state relay.
   c. Split core design.
   d. Trip Setpoint: Fixed.
   e. Output: Digital switch.
   f. Sensor Power: Induced from line.
   g. Manufacturer and Product: Veris; Hawkeye 600/800.
2. Adjustable Setpoint, Digital Output Current Switch:
   a. Application: Monitoring status of belt drive equipment.
   b. Current-operated solid state relay.
   c. Split core design.
   d. Trip Setpoint: Adjustable.
   e. Output: Digital switch, with status LED.
   f. Sensor Power: Induced from line.
   g. Manufacturer and Product: Veris; Hawkeye 708/908.
3. Adjustable Setpoint, Digital Output, AFD Current Switch:
   a. Application: Monitoring status of belt-drive or direct-drive equipment controlled by an AFD.

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b. Microprocessor-based current-operated solid state relay.
c. Automatic compensation for AFD frequency and current changes.
d. Split core design.
e. Trip Setpoint: Self-calibrating.
f. Output: Digital switch, with normal and alarm status LED.
g. Sensor Power: Induced from line.
h. Manufacturer and Product: Veris; Hawkeye 904.

2.06 MISCELLANEOUS DEVICES

A. General:

1. RTD to voltage (0- to 5-volt) converters with zero span adjustments for use with analog inputs.
2. Limited range thermistors are acceptable provided they sense expected range for point at specified accuracy with 0- to 5-volt output.
3. Auxiliary contacts in each motor starter, Work of Division 26, Electrical.
4. START/STOP relay module for either momentary or maintained switch action as indicated.

B. Motorized Step Controllers: Furnish with adjustable (from 1 to 10 degrees F) deadband between heating and cooling functions.

C. Receiver Controllers:

1. Modulating temperature, pressure, or humidity type.
2. Adjustable gain with amplification ratio up to 40 to 1.
3. Dual input (submaster) instruments to have adjustable ratio or reset range.
4. Furnish dials for set point, gain and, where applicable, ratio or reset range.
5. Mount inside HCP.
6. Furnish test probe points to permit analysis of input signal(s) without interrupting controller.
7. Mount pressure gauge on instrument showing output air pressure supplied to controlled device.
8. Include proportional integral control.
    a. Designed to minimize internal hysteresis.
    b. Either integral or remote set point adjustment.
    c. Integral time constant adjustment.
    d. Function as integral feedback device with output that varies progressively, depending on degree of offset and time since transient was detected.
9. Capable of being remotely reset from existing building automation system.

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D. Time Clock (TC):

1. Electronic 7-day programmable type.
2. 8-hour battery backup feature.
3. Mount inside HCP.
4. Manufacturers and Products:
    a. Paragon; **[A: .]**
    b. Omron; **[B: .]**

PART 3 EXECUTION

3.01 INSTALLATION

A. Control Dampers:

1. Install at locations indicated on Drawings and in accordance with manufacturer's instructions.
2. Install square and free from racking with blades running horizontally.
3. Operate opposed blade dampers from a power blade or drive axle.
4. Bracing:
    a. Install for multiple section assemblies to support assembly weight and to hold against system pressure.
    b. Install at every horizontal and vertical mullion.

END OF SECTION

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SECTION 23 09 23
DIRECT-DIGITAL CONTROL SYSTEM FOR HVAC

PART 1 GENERAL

1.01 GENERAL

A. This section is a supplement to Section 23 09 00, Instrumentation and Control Devices for HVAC.

B. The requirements of this Section shall be provided in addition to those listed in Section 23 09 00, Instrumentation and Control Devices for HVAC.

1.02 DEFINITIONS

A. ASCII: ANSI X3.4, Information Systems—Coded Character Sets—7-Bit American National Standard Code for Information Interchange (7-Bit ASCII).

B. BACnet: ASHRAE 135, BACnet, Data Communication Protocol for Building Automation and Control Networks.

C. Distributed Control: System whereby control processing is decentralized and independent of central computer. Control system is built up of standalone controllers. Single controller failure shall not impact more than one system.

D. Ethernet: ISO/IEC 8802-3. The most common high performance peer-to-peer LAN protocol.

E. Integration:

1. Ability of control system components from different manufacturers to connect together and provide coordinated control via real-time data exchange through common communications data exchange protocol.
2. Integration shall extend to operator's workstation software, which shall support user interaction with control system components.
3. Methods of integration include industry standard protocols, such as: BACnet, LonMark/LonTalk, OLE for Process Control (OPC), or integrator interfaces between manufacturer's systems.

F. Interoperability: Ability of equipment to communicate mutually.

G. Input/Output (I/O): Connections between computer and sensors and actuators.

H. Human-Machine Interface (HMI): Method by which operator communicates with HVAC Control System. Allows operator to command, monitor, and program control system.

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I. Internet Protocol (IP): Network layer protocol originally created by Defense Advanced Research Project Agency to facilitate data communication between U.S. Defense Department and defense contractors, including universities and manufacturers.

J. Local Area Network (LAN): Network in which devices can communicate directly without going through intervening routers. LANs commonly used by DDC system Suppliers include Ethernet (ISO 8802-3), ARCNET, Echelon LonTalk, and EIA 485.

K. Master-Slave/Token-Passing (MS/TP): One of the data link layers created specifically for use with BACnet messages.

L. Network:

1. System of distributed control units that are linked together on communication highway.
2. Allows sharing of point information between control units.
3. Provides central monitoring and control of entire system from any distributed control unit location.
4. Primary networks provide peer-to-peer communications.
5. Secondary networks provide either peer-to-peer, master-slave, or supervised token-passing communications.

M. Peripheral: Input/Output equipment used to communicate with computer and make copies of system outputs. Peripherals include CRT, printer, tape deck, diskette.

N. PID (Proportional, Integral, Derivative) Control Loop: Mathematical calculation used to evaluate control input and determine control output value required to maintain input value at set point. Shall have operator adjustable maximum rate of change, P and D gains, and loop response time delay. Loop shall be self-integrating so no integral constant is required and not be subject to integral windup.

O. Transmission Control Protocol (TCP): Connection-oriented protocol used to convey multiple related messages (e.g., file transfers, Web pages, etc.).

P. Abbreviations that may be used in this Section:

1. BIOS: Basic Input Output System.
2. DDC: Direct Digital Control.
3. IBM: International Business Machines, Inc.
4. LCD: Liquid Crystal Display.
5. PC: Personal Computer.

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6. PID: Process Instrumentation Diagram.
7. PI: Pressure Indicator.

1.03 QUALITY ASSURANCE

A. Compatibility:

1. System shall have documented history of compatibility by design for minimum of 15 years.
2. Future compatibility shall be supported for no less than 10 years.
3. Compatibility shall be defined as:
   a. Ability to upgrade existing microelectronic controllers to current level of technology, and extend new microelectronic controllers on previously installed network.
   b. Ability for any existing microelectronic controller microprocessor to be connected and directly communicate with new microelectronic controllers without bridges, routers, or protocol converters.

1.04 SYSTEM PERFORMANCE

A. System shall conform to the following performance standards:

1. Graphic Display:
   a. Minimum of 20 dynamic points.
   b. Current data displayed within 20 seconds of request.
2. Graphic Refresh: System shall update dynamic points with current data within 30 seconds.
3. Object Command:
   a. Maximum time between command of binary object by operator and reaction by device shall be 10 seconds.
   b. Analog objects shall start to adjust within 10 seconds.
4. Object Scan: Changes of state and change of analog values shall be transmitted over high-speed network such that any data used or displayed at controller or workstation will be current, within prior 60 seconds.
5. Alarm Response Time: Maximum time from when object goes into alarm to when it is annunciated at workstation shall not exceed 45 seconds.
6. Program Execution Frequency: Custom and standard applications shall be capable of running as often as once every 5 seconds. Select execution times consistent with mechanical process under control.
7. Performance: Programmable Controllers shall be able to execute DDC PID control loops at selectable frequency from at least once every 5 seconds. Controller shall scan and update process value and output generated by this calculation at this same frequency.

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8. Multiple Alarm Annunciation: Workstations on network shall receive alarms within 5 seconds of each other.
9. Reporting Accuracy: Table 1 lists minimum acceptable reporting accuracies for values reported by specified system.

Table 1
Reporting Accuracy

Measured Variable	Reported Accuracy
Space temperature	±0.5°C [±1°F]
Ducted air	±1.0°C [±2°F]
Outside air	±1.0°C [±2°F]
Water temperature	±0.5°C [±1°F]
Delta-T	±0.15°C [±0.25°F]
Relative humidity	±5% RH
Water flow	±5% of full scale
Air flow (terminal)	±10% of reading[1]
Air flow (measuring stations)	±5% of reading
Air pressure (ducts)	±25 Pa [±0.1" WC]
Air pressure (space)	±3 Pa [±0.01" WC]
Water pressure	±2% of full scale[2]
Electrical Power	5% of reading[3]
Carbon Monoxide (CO)	± 50 PPM
Carbon Dioxide (CO_2)	± 50 PPM

[1](10%-100% of scale) (cannot read accurately below 10%).
[2]For both absolute and differential pressure.
[3]Not including utility supplied meters.

1.05 EXTRA MATERIALS

A. Furnish, tag, and box for shipment and storage the following special tools:

Item	Quantity
Special tools required to maintain or dismantle	One complete set for each different size unit

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PART 2 PRODUCTS

2.01 STANDALONE DDC CONTROL SYSTEM

A. Standalone Custom Controllers:

1. General:
   a. Provide adequate number of controllers to provide performance specified in Article System Performance.
   b. Microprocessor based true no-host system; no PC or “host” computer required to perform control functions or communications, capable of standalone operation, providing control functions without being connected to a network.
2. Performance:
   a. Set points, controller operating system, and programming shall be resident in EEPROM, within controller.
   b. Capable of executing DDC loops and custom control routines.
   c. DDC loop control programming with editable proportional, integral, and derivative control parameters.
   d. DDC loops shall have editable high and low output limits as well as editable failure output values.
   e. Software control reaction time shall be programmable to be no slower than 5 seconds.
   f. DDC loops shall be programmable to operate at user defined intervals with maximum frequency of 1 second.
   g. Sufficient memory to support its operating system, database, and programming requirements.
3. Environment: Controller hardware shall be suitable for anticipated ambient conditions.
   a. Controller shall be mounted in locking enclosure. Refer to Section 23 09 13, HVAC Controls, Field Components, and Instruments, Article HVAC Control Panels (HCP), for enclosure details.
   b. Controller used outdoors or in wet ambient conditions shall be mounted within waterproof enclosure and rated for operation at minus 40 degrees C to 65 degrees C (minus 40 to 150 degrees F).
   c. Controller used in conditioned ambient shall be mounted in dust-proof enclosure and shall be rated for operation at 0 degrees C to 50 degrees C (32 degrees F to 120 degrees F).
4. Clock:
   a. Real time clock that shall remain active during power failure for up to 7 days under normal operating conditions.
   b. When controller is used with higher level system, time clock shall be automatically synchronized with system controller.

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5. Software:
    a. Software for controller setup, programming, and editing of database.
    b. In English language.
    c. IBM PC compatible.
    d. PI and PID control loops.
    e. Programming subroutine blocks available to be used in any combination for program modifications.
    f. As a minimum, routines shall include:
        1) Time- or event-based scheduling.
        2) Offline, fill-in-the-blank programming of controller.
        3) Operating and programming error messages and diagnostics.
        4) Database save and restore.
        5) Adaptive optimum start/stop.
        6) Run time totalization.
        7) Alarm detection and dial out.
        8) Historical Trending: Trend data shall be fully compatible with Microsoft Access and Excel.
    g. Documentation: Provide to Owner, before completion of Project:
        1) Electronic copy of programming tool software.
        2) Electronic copy of control logic program used in controller.
        3) User's manual for software operation.
        4) Include appropriate cable for interconnection between PC serial port and controller.
6. Diagnostics: Controller shall contain the following diagnostic information:
    a. LEDs indicating status of main board, communications Transmit and Receive, and Binary Output on/off.
    b. Information regarding failure of analog or change of state of any binary point. Controller must then capture an image of all points at value or state at time of event/alarm. This data must be able to be viewed from a set of screens that are labeled with alarm point, date and time of occurrence, and cause of failure.
    c. Self test procedure for checking communications and verifying functionality of memory and database.
    d. Upon detection of communication loss, retransmission shall be attempted.
    e. Continuing failure shall cause trouble signal to be annunciated at HCP.
7. External Communication:
    a. Allow service tool editing of programming while controller is in total standalone operation.

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b. Include RS232 port for connection to portable operator interface device for commissioning, adjustment, diagnosis, upload, download, and editing of data.
c. Provide port for connection to LAN.

8. Electrical:
   a. Power:
      1) On/Off switch inside cabinet.
      2) Controller Power: 24V, 50/60 Hz.
      3) On-board isolation transformer or dedicated transformer, rated at minimum of 125 percent of maximum power consumption, and shall be fused or current limiting type.
      4) Battery Backup: Local controller must provide backup of all memory for period of 7 days under normal operating conditions if commercial power to controller is interrupted.
   b. Connections:
      1) Plug-in terminal blocks, in accordance with requirements of Section 23 09 13, HVAC Controls, Field Components, and Instruments, Article HVAC Control Panels (HCP).
      2) Logic card containing active electrical components shall be easily removable from wiring base without use of tools.
      3) Provide quick disconnect interconnection with electrical wiring.
   c. Immunity to Power and Noise:
      1) Controller shall be able to operate at 90 percent to 110 percent of nominal voltage rating and shall perform orderly shutdown below 80 percent nominal voltage.
      2) Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5W at 1 meter (3 feet).
      3) Provide filters, as required to comply with applicable FCC regulations.
   d. Power Loss/Restart:
      1) Tolerant of power failures.
      2) Memory shall be nonvolatile or unit shall hold memory up to 30 days minimum on backup batteries.
      3) When power failure has occurred and power is restored, controller shall restart automatically and without operator intervention.
      4) Restart Procedures:
         a) Come online.
         b) Update monitored functions.
         c) Implement special facility startup strategies as required.
      5) Resume operation based on current time and status.

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9. Input/Output:
    a. Controller shall be configurable using modular Input/Output points to allow for system customization and expansion.
    b. Each controller shall monitor analog inputs and analog outputs, and perform minimum 10 bit A-to-D and 8 bit D-to-A conversion.
    c. Local controller shall receive signals from industry standard sensors and input devices and directly control actuators and control devices.
    d. Controller shall have capability to monitor and control the following types of inputs and outputs:
        1) Analog Inputs:
            a) Current: 4 to 20 mA.
            b) Voltage: 0 to 10 V dc.
            c) Thermistor.
            d) 1,000 Ohm RTD.
        2) Binary Inputs:
            a) Isolated dry contact closure.
            b) Pulse.
        3) Analog Outputs:
            a) Current: 4 to 20 mA.
            b) Voltage: 0 to 10 V dc.
        4) Binary Outputs: 24 V ac, Triac switch.
    e. Output points must be available with manual software and hardware overrides with feedback indication that an output is presently overridden.
    f. Port Isolation:
        1) Individually, electrically isolated to protect against transients, spikes, and power surges.
        2) Optically isolated from each other, controller circuit board, and from power wiring.
        3) Optical isolation either as integral component to controller or as a separate interface device between controller and field wiring.
    g. Quantity of I/O Points: As required to provide equipment function as described in sequences of operation.
10. Expansion Capability:
    a. Capable of accepting expansion modules for addition of:
        1) Memory.
        2) Input/Output points.
11. Trending:
    a. Minimum of eight user selectable points shall be able to be logged, with a minimum of 24 samples per log.
    b. Start and stop times for each trend log shall be definable or continuous.

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12. User Interface:
    a. Local keypad and display shall be provided for each controller for interrogating and editing data.
    b. Keypad and display shall comply with Article, Human Machine Interface (HMI).

B. Human Machine Interface (HMI):

1. Portable Operators Terminal (HMI-1)
    a. Furnish one Portable Operator's Terminal (POT) that shall be capable of accessing system data.
    b. Device may be connected directly to any controller for programming, setup, and troubleshooting.
    c. Capable of accepting user defined, alpha-numeric passcodes, providing discrete user defined levels of security.
    d. Able to display current state of any input/output point connected to controller.
    e. Able to modify current state of any output point connected to controller, given appropriate security level.
    f. Capable of displaying controller status, faults, and diagnostics including:
        1) Communications errors.
        2) Controller software versions.
        3) Input/output point alarms.
        4) Controller operating mode.
        5) Operator interface shall allow display, setup, and/or adjustment of:
            a) Heating and cooling, occupied and unoccupied set points.
            b) Viewing alarms.
            c) Monitoring temperatures, operating modes, on/off statuses, and failure conditions.
            d) Units of temperature.

C. Remote Communications:

1. Provide modem to allow dial-in for complete EIA/TIA 232F access for system monitoring, control, and programming.
2. Possible to retrieve and save system panel's database and to download that database from remote location over standard telephone lines.
3. Enable auto-dial out of alarms including equipment failures and temperatures out-of-range for automatic annunciation and logging at remote location.

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2.02 NETWORK COMMUNICATION

A. Control products for Networked DDC Control System shall comprise a BACnet network. PC Workstations and Building Controller components shall meet ASHRAE 135, BACnet.

B. Operator Workstations and Building Controllers shall be installed on a primary high-speed peer-to-peer ISO 8802-3 Ethernet network.

C. Custom Application Controllers and Application Specific Controllers may be installed on either primary high-speed peer-to-peer ISO 8802-3 Ethernet network, or Secondary network.

D. Provide all communication media, connectors, repeaters, hubs, and routers necessary for network.

E. Building Controllers shall have communications port for connections with operator interfaces using BACnet Data Link/Physical layer protocol.

F. Provide device on network with minimum 28,000 baud modem that will allow remote operator interface using BACnet Data Link/Physical layer protocol. Modem shall allow for communication with controllers on this network as described below.

G. Communications services over network shall result in operator interface and value passing that is transparent to network architecture as follows:

1. Connection of operator interface device to any one controller on network shall allow operator to interface with other controllers as if that interface were directly connected to other controllers.
2. Data, status information, reports, system software, custom programs for controllers shall be available for viewing and editing from any controller on network.
3. Database values (i.e., points, software variable, custom program variables) of any one controller shall be readable by any other controller on network.
4. This value passing shall be automatically performed by controller when reference to point name not located in that controller is entered into controller’s database.
5. Operator/installer shall not be required to set up any communications services to perform network value passing.

H. Time clocks in controllers shall be automatically synchronized daily.

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2.03 NETWORK HUMAN-MACHINE INTERFACE

A. Operator Interface:

1. Furnish PC based operator workstation.
2. Workstation shall be able to access all information in system.
3. Workstation shall reside on same high-speed network as building controllers, and shall also be able to dial into system.

B. Communications:

1. Workstation information access shall use BACnet Protocol.
2. Communication shall use ISO 8802-3 (Ethernet).
3. Remote communications shall use BACnet Point to Point Physical/Data Link Layer Protocol.

C. Hardware: Each operator workstation shall consist of the following:

1. Personal Computer:
   a. Furnish **[A: one] [B:]** IBM compatible PC.
   b. Features:
      1) Monitor: 17-inch, minimum, SVGA.
      2) CPU: Intel Pentium 4, minimum, and operate at a minimum of 1.6 GHz.
      3) RAM: 256 Megabytes, minimum.
      4) Diskette Drive: One with 1.44 Megabytes capacity.
      5) Optical Drive: 40X speed, CD-ROM.
      6) Hard Drive: 10 GigaByte capacity, minimum, with minimum access time of 12 milliseconds.
      7) Mouse: Two button.
   c. Furnish required serial, parallel, and network communication ports, and cables for proper system operation.
2. Modem:
   a. Auto-dial telephone modem and associated cables as required for communication to remote buildings, and workstations.
   b. Transmit at minimum of 56,000 baud, and communicate over voice-grade telephone lines.
3. BACnet:
   a. Workstation shall use Read (Initiate) and Write (Execute) Services as defined in Clauses 15.5 and 15.8, respectively, of ASHRAE 135, to communicate with BACnet objects in network.
   b. Objects supported shall include: Analog input, analog output, analog value, binary input, binary output, binary value, and device.

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D. System Software:

1. Operating System:
    a. Commercially available, concurrent multitasking.
    b. Support use of other common software applications that operate under DOS or Microsoft Windows.
2. System Graphics:
    a. Operator workstation software shall be graphically oriented.
    b. System shall allow display of up to 10-graphic screens at once for comparison and monitoring of system status.
    c. Provide method for operator to easily move between graphic displays and change size and location of graphic displays on screen.
    d. Able to be modified while on line.
    e. Operator with proper password level shall be able to add, delete, or change dynamic points on graphic.
    f. Dynamic points shall include analog and binary values, dynamic text, static text, video and animation files.
    g. Ability to show animation of equipment.
3. Custom Graphics:
    a. Created with use of commonly available graphics packages, such as PC Paint.
    b. Graphics generation package shall create and modify graphics that are saved in industry standard formats such as PCX, BMP, GIF, and JPEG.
    c. Graphics generation package shall also provide capability of capturing or converting graphics from other programs such as Designer, or AutoCAD.
4. Graphics Library:
    a. Complete library of standard HVAC equipment such as chillers, boilers, air handlers, terminals, fan coils, and unit ventilators.
    b. Include standard symbols for other equipment including fans, pumps, coils, valves, piping, dampers, and ductwork.
    c. File format compatible with graphics generation package program.
5. Engineering Units:
    a. Allow for selection of desired engineering units (i.e., inch pound or SI) in system.
    b. Unit selection shall be able to be customized by locality to select desired units for each measurement.
    c. Engineering units on this project shall be Standard Inch Pound.

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E. System Applications. Each workstation shall provide operator interface and offline storage of system information. Provide the following applications at each workstation:

1. Automatic System Database Save and Restore:
    a. Store on hard disk copy of current database of each building controller.
    b. Database shall be updated whenever change is made in any panel in system.
    c. Storage of data shall be automatic and not require operator intervention.
    d. In the event of database loss in building management panel, first workstation to detect loss shall automatically restore database for that panel.
2. Manual Database Save and Restore:
    a. System operator with proper password clearance shall be able to archive database from any system panel and store on magnetic media.
    b. Operator shall also be able to clear panel database and manually initiate download of specified database to any panel in system.
3. System Configuration:
    a. Workstation software shall provide graphical method of configuring system.
    b. User with proper security shall be able to add new devices and assign modems to devices.
    c. This shall allow for future system changes or additions.
4. Online Help:
    a. Context sensitive to assist operator in operation and editing of system.
    b. Available for all applications and shall provide relevant data for that particular screen.
    c. Additional help information shall be available through use of hypertext.
5. Security:
    a. Each operator shall be required to log on to system with user name and password in order to view, edit, add, or delete data. System security shall be selectable for each operator.
    b. System supervisor shall have ability to set passwords and security levels for other operators.
    c. Each operator password shall be able to restrict operators' access for viewing and/or changing each system application, full screen editor, and object.
    d. Each operator shall automatically be logged off system if no keyboard or mouse activity is detected.

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e. Auto logoff time shall be set per operator password.
f. System security data shall be stored in encrypted format.

6. System Diagnostics:
   a. System shall automatically monitor operation of workstations, printers, modems, network connections, building management panels, and controllers.
   b. Failure of any device shall be annunciated to operator.
7. Alarm Processing:
   a. Any object in system shall be configurable to alarm in and out of normal state.
   b. Operator shall be able to configure alarm limits, warning limits, states, and reactions for each object in system.
   c. Alarm Reactions:
      1) Operator shall be able to determine what actions, if any, are to be taken, by object (or point), during alarm.
      2) Actions shall include logging, printing, starting programs, displaying messages, dialing out to remote stations, paging, providing audible annunciation, or displaying specific system graphics.
      3) Each of these actions shall be configurable by workstation and time of day.
      4) Object in alarm that has not been acknowledged within operator specified time period shall be rerouted to alternate operator specified alarm receipt device.
   d. Binary Alarms:
      1) Each binary object shall be set to alarm based on operator specified state.
      2) Capability to disable alarming when associated equipment is turned off or is being serviced.
   e. Analog Alarms:
      1) Each analog object shall have both high and low alarm limits and warning limits.
      2) Alarming must be able to be automatically and manually disabled.
8. Trend Logs:
   a. Operator shall be able to define custom trend log for any data in system.
   b. This definition shall include interval, start-time, and stop-time. Trend intervals of 1, 5, 15, 30, and 60 minutes as well as once a shift (8 hours), once a day, once a week, and once a month shall be selectable.
   c. Trends shall start based on the hour. Each trend shall accommodate up to 64 system objects.
   d. System operator with proper password shall be able to determine how many samples are stored in each trend.

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e. Trend Data:
    1) Sampled and stored on building controller panel, and archived on hard disk.
    2) Able to be viewed and printed from operator interface software.
    3) Storable in tab delimited ASCII format for use by other industry standard word processing and spreadsheet packages.

9. Alarm and Event Log:
    a. Operator shall be able to view logged system alarms and events from any location in system.
    b. Events shall be listed chronologically.
    c. Operator with proper security level may acknowledge and clear alarms.
    d. All that have not been cleared by operator shall be archived to hard disk on workstation.
10. Object and Property Status and Control:
    a. Provide method for operator with proper password protection to view, and edit if applicable, status of any object and property in system.
    b. Statuses shall be available by menu, on graphics, or through custom programs.
11. Clock Synchronization:
    a. Real time clocks in building control panels and workstations shall be synchronized on command of operator.
    b. System shall also be able to automatically synchronize system clocks daily from any operator-designated device in system.
    c. System shall automatically adjust for daylight savings and standard time, if applicable.
12. Reports and Logs:
    a. Reporting package shall allow operator to select, modify, or create reports.
    b. Each report shall be definable as to data content, format, interval, and date.
    c. Report data shall be archived on hard disk for historical reporting.
    d. Ability for operator to obtain real time logs of designated lists of objects.
    e. Reports and logs shall be stored on PC hard disk in format that is readily accessible by other standard software applications, including spreadsheets and word processing.
    f. Reports and logs shall be readily printed to system printer.
    g. Operator shall be able to designate reports that shall be printed or stored to disk at selectable intervals.

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h. Custom Reports:
   1) Capable for operator to easily define any system data into daily, weekly, monthly, or annual report.
   2) Time and date stamped, and shall contain report title and name of facility.

i. Standard Reports: The following standard system reports shall be provided for this Project. Reports shall be readily customized to Project by Owner.
   1) Electrical Meter Report:
      a) Monthly report showing daily electrical consumption and peak electrical demand for each building meter.
      b) Annual (12 months) summary report showing monthly electrical consumption and peak demand for each meter.
   2) Gas Meter Report:
      a) Monthly report showing daily natural gas consumption for each meter.
      b) Annual (12 months) report showing monthly consumption for each meter.
   3) Weather Data Report:
      a) Monthly report showing daily minimum, maximum, and average outdoor air temperature, and number of heating and cooling degree-days for each day.
      b) Annual (12 months) report showing minimum, maximum, and average outdoor air temperature for month, and number of heating and cooling degree days for each month.
   4) Tenant Override Reports:
      a) Monthly report showing daily total time in hours that each tenant has requested after-hours HVAC and lighting services.
      b) Annual (12 months) report that shows override usage on monthly basis.
   5) ASHRAE Guideline 3 Report: Daily report that shows operating condition of each chiller as required by ASHRAE Guideline 3. At minimum this report shall include:
      a) Chilled Water (or other fluid) inlet and outlet temperature.
      b) Chilled Water (or other fluid) flow.
      c) Chilled Water (or other fluid) inlet and outlet pressures.
      d) Evaporator refrigerant pressure and temperature.
      e) Condenser refrigerant pressure and liquid temperature.
      f) Condenser water inlet and outlet temperatures.

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g) Condenser water flow.
h) Refrigerant levels.
i) Oil pressure and temperature.
j) Oil level (if applicable).
k) Compressor refrigerant discharge temperature.
l) Compressor refrigerant suction temperature.
m) Manual entry field for addition of refrigerant.
n) Manual entry field for addition of oil.
o) Manual entry field for vibration levels.
p) Motor amperes per phase.
q) Motor volts per phase.
r) PPM refrigerant monitor levels.
s) Purge exhaust time or discharge count.
t) Ambient temperatures (dry bulb and wet bulb).
u) Date and time data logged.

F. Workstation Applications Editor:

1. General:
   a. Each PC workstation shall support full screen editing of system applications.
   b. Editor for each application at PC workstation.
   c. Applications shall be downloaded and executed at appropriate controller panels.
   d. Full screen editor for each type controller and application that shall allow operator with proper password to view and change configuration, name, control parameters, and system set points.
2. Scheduling:
   a. Editor for scheduling application shall be provided at each workstation.
   b. Monthly calendar for each schedule.
   c. Exception schedules and holidays shall be shown clearly on calendar.
   d. Capable of allowing several related objects to follow a schedule.
   e. Advance and delay time for each object shall be adjustable from this master schedule.
   f. Operator with proper password level shall be able to modify schedule.
   g. Schedules shall be able to be easily copied between objects and/or dates.
3. Equipment Coordination:
   a. Full screen editor shall allow equipment to be grouped for proper operation as specified in sequence of operations.
   b. Include coordination of VAV boxes with their associated Air Handling Equipment.

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4. Chiller System: Chiller plant control application shall be configured using full screen editor and shall provide operating status for system. Display shall include:
    a. System mode of chiller plant.
    b. Chiller enable/disable status.
    c. System supply water set point.
    d. System supply and return water temperature.
    e. System chilled water pump status.
    f. System chilled water flow.
    g. Bypass pipe flow rate (if applicable).
    h. Current chiller plant control operation.
    i. Add information.
    j. Subtract information.
    k. System failure information.
    l. Chiller failure information.
    m. Rotation information.
    n. Override capabilities to force an add control, subtract control, or change of sequence.
    o. Remove chiller from sequence temporarily for service purposes.
5. Custom Application Programming:
    a. Provide tools to create, modify, and debug custom application programming.
    b. Operator shall be able to create, edit, and download custom programs at same time that other system applications are operating.
    c. System shall be fully operable while custom routines are edited, compiled, and downloaded.
    d. Programming language shall have the following features:
        1) English language oriented and based on syntax of programming languages such as BASIC. It shall allow for free form or fill in the blank programming. Alternatively, programming language can be graphically based using function blocks as long as blocks are available that directly provide functions listed below, and that custom or compound function blocks can be created.
        2) Full screen character editor/programming environment. Editor shall be cursor/mouse driven and allow user to insert, add, modify, and delete code from custom programming. It shall also incorporate word processing features such as cut/paste and find/replace.
        3) Allow independently executing program modules to be developed. Each module shall be able to independently enable and disable other modules.
        4) Editor/programming environment shall have debugging/simulation capability that allows user to step

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through program and to observe intermediate values and results. Debugger shall also provide error messages for syntax and execution errors.

5) Support conditional statements (if/then/else/else-if) using compound Boolean (and, or, and not) and/or relations (equal, less than, greater than, not equal) comparisons.
6) Support floating point arithmetic using the following operators: +, -, /, x, square root, and xy.
7) The following mathematical functions shall also be provided: natural log, log, absolute value, and minimum/maximum value from a list of values.
8) Predefined variables that represent clock time, day of week, and date. Variables that provide interval timing shall also be available. Language shall allow for computations using these values.
9) Ability to predefined variables representing status and results of System Software, and shall be able to enable, disable, and change values of BACnet objects in system.

G. Portable Operator's Terminal:

1. Provide one capable of accessing system data.
2. Ability to connect to any point on system network or directly to any controller for programming, setup, and troubleshooting.
3. BACnet:
   a. Shall use Read (Initiate) and Write (Execute) Services as defined in Clauses 15.5 and 15.8, respectively, of ASHRAE 135, to communicate with BACnet objects in network.
   b. Objects supported shall include: Analog input, analog output, analog value, binary input, binary output, binary value, and device.
4. IBM compatible notebook-style PC, including software and hardware required. PC shall contain at minimum:
   a. 200 MHz Intel Pentium Processor.
   b. 32 MB RAM.
   c. 500 MB Hard Drive.
   d. 3.5-inch, 1.44 MB, Floppy Disk Drive.
   e. 4X CD-ROM Drive.

2.04 NETWORKED DDC CONTROLLERS

A. Controller Software:

1. General:
   a. Provide applications software for building and energy management.

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b. Software applications shall reside and run in system controllers.
c. Editing of applications shall occur at operator workstation.

2. System Security:
   a. User access shall be secured using individual security passwords and user names.
   b. Passwords shall restrict user to only objects, applications, and system functions as assigned by system manager.
   c. User logon/logoff attempts shall be recorded.
   d. System shall protect itself from unauthorized use by automatically logging off following last keystroke. Delay time shall be user definable.
3. Scheduling:
   a. General:
      1) Provide capability to schedule each object or group of objects in system.
      2) Each schedule shall include capability for start, stop, optimal start, optimal stop, and night economizer actions.
      3) Each schedule may consist of up to 10 events.
      4) When group of objects are scheduled together, provide capability to define advances and delays for each member.
   b. Weekly Schedule: Separate schedules for each day of the week.
   c. Exception Schedule:
      1) Ability for operator to designate any day of the year as an exception schedule.
      2) Shall override standard schedule for that day.
      3) May be defined up to a year in advance.
      4) Once executed, it will be discarded and replaced by standard schedule for that day of the week.
   d. Holiday Schedule:
      1) Capability for operator to define up to 99 special or holiday schedules.
      2) May be placed on scheduling calendar and repeated each year.
      3) Operator shall be able to define length of each holiday period.
   e. Optimal Start/Stop:
      1) Calculate thermal characteristics of zone and start equipment prior to occupancy to achieve desired space temperature at specified occupancy time.
      2) Algorithm shall calculate separate sets of heating and cooling rates for zones that have been unoccupied for less than and greater than 24 hours.
      3) Ability to modify start/stop algorithm based on outdoor air temperature.

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4) Early start limit in minutes to prevent system from starting before operator determined time limit.

4. Alarm Reporting:
   a. Operator shall be able to determine action to be taken in event of alarm.
   b. Alarms shall be routed to appropriate workstations based on time and other conditions.
   c. Alarm shall be able to start programs, be logged in event log, printed, display custom messages or graphics.
5. Remote Communications:
   a. Ability to dial out in event of alarm.
   b. Receivers shall include PC Workstations and alpha-numeric pagers.
   c. Alarm message shall include name of calling location, device that generated alarm, and alarm message itself.
   d. Operator shall be ably to remotely access and operate system using dial-up communications in same format and method used on Site under Paragraph Operator Interface.
6. Demand Limiting:
   a. Monitor building power consumption from signals generated by pulse generator (provided by others) mounted at building power meter, or from watt transducer, or current transformer attached to building feeder lines.
   b. Based on predictive sliding window algorithm. Sliding window duration and sampling interval shall be set equal to that of local electrical utility.
   c. Control system shall be capable of demand limiting by resetting HVAC system set points to reduce load while maintaining indoor air quality (humidity, VOC, CO_2), and comfort control in space.
   d. Input capability shall also be provided for end-of-billing period indication.
7. Maintenance Management: System shall monitor equipment status and generate maintenance messages based upon user designated run time, starts, and/or calendar date limits.
8. PID (Proportional-Integral-Derivative) Control:
   a. Algorithm with direct or reverse action, and anti-wind-up.
   b. Algorithm shall calculate time-varying analog value used to position output or stage series of outputs.
   c. Controlled variable, set point, and PID gains shall be user-selectable.
   d. Set point shall optionally be chosen to be reset schedule.
9. Staggered Start: Shall prevent controlled equipment from simultaneously restarting after power outage. Order that equipment (or groups of equipment) is started, along with time delay between starts shall be user-selectable.

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10. System Calculations:
    a. Software to allow instantaneous power (e.g., kW), to be accumulated and converted to energy usage data.
    b. Algorithm shall calculate the following:
        1) Sliding-window kW demand value.
        2) Energy usage and weather data (heating and cooling degree days).
        3) Items shall all be available for daily, previous day, monthly and previous month.
11. Anti-Short Cycling: Binary output points shall be protected from short cycling. This feature shall allow minimum on-time and off-time to be selected.

B. Building Controllers:

1. General:
    a. Performance:
        1) Provide adequate number of Building Controllers to provide performance specified in Article System Performance.
        2) Manage global strategies described in Article Controller Software.
        3) Microprocessor based, capable of stand-alone operation, and shall continue to provide control functions without being connected to network.
    b. Sufficient memory to support its operating system, database, and programming requirements.
    c. Data shall be shared between networked Building Controllers.
    d. Operating system of Controller shall manage input and output communications signals to allow distributed controllers to share real and virtual point information and allow central monitoring and alarms.
    e. Controllers that perform scheduling shall have real time clock.
    f. Continually check status of its processor and memory circuits. If abnormal operation is detected, controller shall:
        1) Assume predetermined failure mode.
        2) Generate alarm notification.
    g. BACnet:
        1) Building Controller shall communicate with other BACnet objects on primary network using Read (Execute and Initiate) and Write (Execute and Initiate) Property services as defined in Clauses 15.5 and 15.8, respectively, of ASHRAE 135.
        2) Objects supported shall include: Analog input, analog output, analog value, binary input, binary output, binary value, and device.

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2. Communications:
    a. Each Building Controller shall reside on primary high-speed peer to peer BACnet network using the ISO 8802-3 (Ethernet) network.
    b. Each Building Controller shall also perform **[E: BACnet]** routing if connected to secondary network of Custom Application and Application Specific Controllers.
    c. Building Controller shall provide service communications port for connection to Portable Operators Terminal using point-to-point BACnet physical/data link layer protocol.
3. Environment: Controller hardware shall be suitable for anticipated ambient conditions.
    a. Controller used outdoors and/or in wet ambient conditions shall be mounted within waterproof enclosure and shall be rated for operation at minus 40 degrees C to 65 degrees C (minus 40 degrees F to 150 degrees F).
    b. Controller used in conditioned ambient shall be mounted in dust-proof enclosure and shall be rated for operation at 0 degrees C to 50 degrees C (32 degrees F to 120 degrees F).
4. Keypad:
    a. Local keypad and display shall be provided for each controller.
    b. Provided for interrogating and editing data.
    c. Optional system security password shall be available to prevent unauthorized use of keypad and display.
    d. If manufacturer does not provide keypad display, provide portable operator terminal.
5. Serviceability: Provide diagnostic LEDs for power, communications, and processor. Wiring connections shall be made to field removable, modular terminal strips or to termination card connected by ribbon cable.
6. Memory: Building Controller shall maintain BIOS and programming information in event of power loss for at least 72 hours.
7. Immunity to Power and Noise:
    a. Controller shall be able to operate at 90 percent to 110 percent of nominal voltage rating and shall perform orderly shutdown below 80 percent nominal voltage.
    b. Operation shall be protected against electrical noise of 5 Hz to 120 Hz and from keyed radios up to 5 watts at 1 meter (3 feet).
8. Transformer: Power supply for Controller shall be rated at minimum of 125 percent of maximum power consumption, and shall be fused or current limiting type.

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C. Custom Application Controllers:

1. General:
    a. Performance:
        1) Provide adequate number of Custom Application Controllers to provide performance specified in Article System Performance.
        2) Shall manage local strategies described in Article Controller Software.
        3) Microprocessor based, capable of standalone operation, and shall continue to provide control functions without being connected to network.
    b. Sufficient memory to support its operating system, database, and programming requirements.
    c. Data shall be shared between networked Controllers.
    d. Operating system of Controller shall manage input and output communications signals to allow distributed controllers to share real and virtual point information and allow central monitoring and alarms.
    e. Controllers that perform scheduling shall have real-time clock.
    f. Continually check status of its processor and memory circuits. If abnormal operation is detected, Controller shall:
        1) Assume predetermined failure mode.
        2) Generate alarm notification.
    g. BACnet:
        1) Controller shall communicate with other BACnet objects on primary network using Read (Execute and Initiate) and Write (Execute and Initiate) Property services as defined in Clauses 15.5 and 15.8, respectively, of ASHRAE 135.
        2) Objects supported shall include: Analog input, analog output, analog value, binary input, binary output, binary value, and device.
2. Communications:
    a. Each Controller shall reside on secondary BACnet network using MS/TP EIA 485, Data Link/Physical layer protocol network.
    b. Controller shall provide service communications port for connection to Portable Operator's Terminal using BACnet Data Link/Physical layer protocol.
3. Environment: Controller hardware shall be suitable for anticipated ambient conditions.
    a. Controller used outdoors and/or in wet ambient conditions shall be mounted within waterproof enclosure and shall be rated for operation at minus 40 degrees C to 65 degrees C (minus 40 degrees F to 150 degrees F).

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b. Controller used in conditioned ambient shall be mounted in dust-proof enclosure and shall be rated for operation at 0 degrees C to 50 degrees C (32 degrees F to 120 degrees F).

4. Keypad:
   a. Local keypad and display shall be provided for each controller.
   b. Provided for interrogating and editing data.
   c. Optional system security password shall be available to prevent unauthorized use of keypad and display.
   d. If manufacturer does not provide keypad display, provide portable operator terminal.
5. Serviceability: Provide diagnostic LEDs for power, communications, and processor. Wiring connections shall be made to field removable, modular terminal strips or to termination card connected by ribbon cable.
6. Memory: Controller shall maintain BIOS and programming information in event of power loss for at least 72 hours.
7. Immunity to Power and Noise:
   a. Controller shall be able to operate at 90 percent to 110 percent of nominal voltage rating and shall perform orderly shutdown below 80 percent nominal voltage.
   b. Operation shall be protected against electrical noise of 5 Hz to 120 Hz and from keyed radios up to 5 watts at 1 meter (3 feet).
8. Transformer: Power supply for Controller shall be rated at minimum of 125 percent of maximum power consumption, and shall be fused or current limiting type.

D. Application Specific Controllers:

1. General:
   a. Performance:
      1) Provide number of Application Specific Controllers to provide performance specified in Article System Performance and as indicated on Drawings.
      2) Microprocessor based, capable of standalone operation and shall continue to provide control functions without being connected to network.
   b. Contain sufficient I/O capacity to control target system.
   c. BACnet:
      1) Controller shall communicate with other BACnet objects on primary network using Read (Execute and Initiate) and Write (Execute and Initiate) Property services as defined in Clauses 15.5 and 15.8, respectively, of ASHRAE 135.
      2) Objects supported shall include: Analog input, analog output, analog value, binary input, binary output, binary value, and device.

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2. Communications.
    a. Each Controller shall reside on secondary BACnet network using MS/TP EIA 485, Data Link/Physical layer protocol network.
    b. Controller shall provide service communications port for connection to Portable Operators Terminal using BACnet Data Link/Physical layer protocol. Connection shall be extended to space temperature sensor where shown.
    c. Environment: Controller hardware shall be suitable for anticipated ambient conditions.
    d. Controller used outdoors and/or in wet ambient conditions shall be mounted within waterproof enclosure and shall be rated for operation at minus 40 degrees C to 65 degrees C (minus 40 degrees F to 150 degrees F).
    e. Controller used in conditioned ambient shall be mounted in dust-proof enclosure and shall be rated for operation at 0 degrees C to 50 degrees C (32 degrees F to 120 degrees F).
3. Serviceability: Provide diagnostic LEDs for power, communications, and processor. Wiring connections shall be made to field removable, modular terminal strips or to termination card connected by ribbon cable.
4. Memory: Controller shall use nonvolatile memory and maintain BIOS and programming information in event of power loss.
5. Immunity to Power and Noise:
    a. Controller shall be able to operate at 90 percent to 110 percent of nominal voltage rating and shall perform orderly shutdown below 80 percent nominal voltage.
    b. Operation shall be protected against electrical noise of 5 Hz to 120 Hz and from keyed radios up to 5 watts at 1 meter (3 feet).
6. Transformer: Power supply for Controller shall be rated at minimum of 125 percent of maximum power consumption and shall be fused or current limiting type.

E. Controller Input/Output Interface:

1. Hard-wired inputs and outputs may tie into system through Building, Custom, or Application Specific Controllers.
2. Protected such that shorting of point to itself, another point, or ground will cause no damage to Controller.
3. Protected from voltage up to 24V of any duration, such that contact with this voltage will cause no damage to Controller.
4. Binary Inputs:
    a. Shall allow monitoring of on/off signals from remote devices.
    b. Shall provide wetting current of at least 12 mA to be compatible with commonly available control devices.

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5. Pulse Accumulation Input Points: Conform to requirements of Binary Input points and accept up to two pulses per second for pulse accumulation, and shall be protected against effects of contact bounce and noise.
6. Analog Inputs:
    a. Allow monitoring of low voltage (0-10 Vdc), current (4-20 mA), or resistance signals (thermistor, RTD).
    b. Compatible with and field configurable to commonly available sensing devices.
7. Binary Outputs:
    a. Provide for on/off operation or pulsed low voltage signal for pulse width modulation control.
    b. Binary outputs on custom and building controllers shall have three-position (on/off/auto) override switches and status lights.
    c. Selectable for either normally-open or normally-closed operation.
8. Analog Outputs:
    a. Shall provide a modulating signal for control of end devices.
    b. Shall provide either 0-10 Vdc or 4-20 mA signal as required to provide proper control of output device.
    c. Building or custom programmable controllers shall have status lights and two-position (auto/manual) switch and manually adjustable potentiometer for manual override.

PART 3 EXECUTION

3.01 GENERAL

A. Refer to Section 23 09 00, Instrumentation and Control Devices for HVAC, for requirements.

END OF SECTION

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SECTION 23 21 13.01
HYDRONIC PIPING SCHEDULE

Legend	Service	Size(s) (In.)	Exposure	Piping Material	Specification Section	Operating Pressure (psig)	Test Type	Test Pressure (psig)	Pipe Colors and Labels	Notes
CD	CONDENSATE DRAIN, HVAC	ALL	EXP/BUR	COP	23 21 13.04	NA	H	5		
CD	CONDENSATE DRAIN, HVAC	90	EXP/BUR	PVC-DWV	22 10 03	NA	H	5		
CHR/CHS	CHILLED WATER, RETURN/SUPPLY	ALL	BUR	PVC	23 21 13.05					
CHR/CHS	CHILLED WATER, RETURN/SUPPLY	ALL	BUR	HDPE	23 21 13.07					
CHR/CHS	CHILLED WATER, RETURN/SUPPLY	2" OR LESS	EXP	STL or COP	23 21 13.02 or 23 21 13.04					
CHR/CHS	CHILLED WATER, RETURN/SUPPLY	2-1/2" OR GREATER	EXP	STL	23 21 13.02					
CWR/CWS	CONDENSER WATER, RETURN/SUPPLY	ALL	BUR	HDPE	23 21 13.07					High Purity Polypropylene
CWR/CWS	CONDENSER WATER, RETURN/SUPPLY	2" OR LESS	EXP	STL or COP	23 21 13.02 or 23 21 13.04					
CWR/CWS	CONDENSER WATER, RETURN/SUPPLY	2-1/2" OR GREATER	EXP	STL	23 21 13.02					
HHR/HHS	HEATING HOT WATER, RETURN/SUPPLY	ALL	BUR	STL	23 21 13.02					
HHR/HHS	HEATING HOT WATER, RETURN/SUPPLY	2" OR LESS	EXP	STL or COP	23 21 13.02 or 23 21 13.04					
HHR/HHS	HEATING HOT WATER, RETURN/SUPPLY	2-1/2" OR GREATER	EXP	STL	23 21 13.02					
RL/RS	REFRIGERANT, LIQUID/SUCTION	ALL	EXP/BUR	CU-ACR	23 23 00	Note 1	Note 1	Note 1		Note 1

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SECTION 23 21 13.01
HYDRONIC PIPING SCHEDULE

Legend	Service	Size(s) (In.)	Exposure	Piping Material	Specification Section	Operating Pressure (psig)	Test Type	Test Pressure (psig)	Pipe Colors and Labels	Notes
SL	STEAM, LOW PRESSURE	ALL	EXP/BUR	STL	23 21 13.03	15				
SM	STEAM, MEDIUM PRESSURE	ALL	EXP/BUR	STL	23 21 13.03	100				
SH	STEAM, HIGH PRESSURE	ALL	EXP/BUR	STL	23 21 13.03	300				
SC	STEAM CONDENSATE	ALL	EXP/BUR	STL	23 21 13.03					
SC	STEAM CONDENSATE	ALL	EXP/BUR	NC STL	23 21 13.08					Corrosive Service

Note 1: Refer to Section 23 23 00, Refrigerant Piping, for testing requirements.

LEGEND:

Exposure	Pressure Test	Material
BUR Buried	H Hydrostatic	COP Copper
EXP Exposed	I In Service	CU-ACR Copper, Air Conditioning and Refrigeration
SUB Submerged	P Pneumatic	CPVC Chlorinated PVC
ENC Concrete Encased	NA Not Applicable	DI Ductile Iron
		FRP Fiberglass Reinforced Plastic
		GSP Galvanized Steel Pipe
		HDPE High Density Polyethylene
		PVC Polyvinyl Chloride
		SST Stainless Steel
		STL Carbon Steel
		NC STL Nickel-Copper Alloy Steel

END OF SECTION

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SECTION 23 23 00
REFRIGERANT PIPING

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Air-Conditioning, Heating, and Refrigeration Institute (AHRI): 760, Performance Rating of Solenoid Valves for Use with Volatile Refrigerants.
2. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE): 15, Safety Standard for Refrigeration Systems.
3. American Society of Mechanical Engineers (ASME):
   a. B16.22, Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.
   b. B31.5, Refrigeration Piping and Heat Transfer Components.
4. American Welding Society (AWS):
   a. A5.8M/A5.8, Specification for Filler Metals for Brazing and Braze Welding.
   b. BRH, Brazing Handbook.
5. ASTM International (ASTM): B280, Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service.
6. National Electrical Manufacturers Association (NEMA).
7. Underwriters Laboratories Inc. (UL).

1.02 DEFINITIONS

A. ACR: Air conditioning and refrigeration.

B. NRTL: National Recognized Testing Laboratory.

1.03 SUBMITTALS

A. Action Submittals:

1. Manufacturer’s data on refrigerant piping, piping products, thermostatic expansion valves, solenoid valves, hot-gas bypass valves, filter dryers, strainers, pressure regulating valves and accessories.

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B. Informational Submittals:

1. Welding certificates.
2. Field quality control; test report.
3. Operation and Maintenance Data as specified in Section 01 78 23, Operation and Maintenance Data.

1.04 QUALITY ASSURANCE

A. Safety Code Compliance: Comply with applicable portions of ASHRAE 15.

B. Brazing: Comply with applicable requirements of ASME B31.5 pertaining to brazing of refrigerant piping for shop and Project Site locations.

C. Installer: A firm with at least 5 years of successful installation experience on projects with refrigerant piping similar to that required for this Project.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Refrigerant piping shall be cleaned, dehydrated, and sealed when delivered.

B. Store piping in clean and protected area with end caps in place.

PART 2 PRODUCTS

2.01 MATERIALS

A. Material and dimensional requirements for field assembled refrigerant piping, valves, fittings and accessories shall conform to ASHRAE 15 and ASME B31.5, except as hereinafter specified.

B. Piping, 3 Inches and Smaller: Copper, Type ACR tube, ASTM B280, copper No. 122, hard-drawn temper. Brazed joints required.

C. Fittings for Copper Tube: Wrought-copper/bronze solder-joint fittings in accordance with ASME B16.22.

D. Pipe Insulation: Refer to Section 22 07 00, Building Mechanical Thermal Insulation.

2.02 MISCELLANEOUS PIPING PRODUCTS

A. Brazing Materials:

1. Except as otherwise indicated, provide 15 percent silver alloy brazing material for copper to copper and copper to brass fittings.
2. Comply with AWS A5.8M/A5.8 for brazing filler materials.

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B. Refrigerant Specialties:

1. Refrigerant Suction Line Filter-Dryer:
   a. Provide steel shell, corrosion-resistant finish filter-dryer, with molded felt core with 10-micron particle retention, in size and working pressure indicated, with copper connectors, and access valve (not applicable for heat pump system).
   b. Operating Temperature Rating: 240 degrees F.
   c. Working Pressure: 500 psi.
   d. Provide size recommended by refrigeration equipment manufacturer.
2. Refrigerant Liquid Line Dryer:
   a. Provide refrigerant liquid line filter-dryer for all units.
   b. Operating Temperature Rating: 240 degrees F.
   c. Working Pressure: 500 psi.
   d. For heat pumps, provide biflow directional types (not required if included with air-conditioning equipment).
   e. Provide size recommended by refrigeration equipment manufacturer.

C. Refrigerant Valves:

1. Globe and Check Valves: Listed and labeled by an NRTL.
   a. Shutoff Valves:
      1) Forged brass, packed, back seating winged seal cap, 300 degrees F (140 degrees C) temperature rating 500 psi working pressure.
      2) Maximum Opening Pressure: 0.5 psig.
      3) Valve required only if shutoff service valves are not included with package air-conditioning equipment.
   b. Manufacturers:
      1) Henry Technologies.
      2) Parker Hannifin Corp.
2. Solenoid Valve: Listed and labeled by an NRTL.
   a. Two-Way Solenoid Valves: Forged brass, designed to conform to AHRI 760, normally closed, Teflon valve seat, NEMA 1 solenoid enclosure, 24 volts, 60-Hz, UL Listed, 1/2-inch conduit adapter, 250 degrees F (121 degrees C) temperature rating 500 psi working pressure.
   b. Provide valve only if recommended by air-conditioning equipment manufacturer.
   c. Manual Operator: Provide optional manual operator to open valve.
   d. Manufacturers:
      1) Alco Controls Div.; Emerson Electric Co.
      2) Automatic Switch Co.
      3) Parker Hannifin Corp.

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3. Thermostatic Expansion Valve:
    a. Body Bonnet and Seal Cap: Forged brass or steel.
    b. Diaphragm, Piston, Closing Spring and Seat Insert: Stainless steel.
    c. Capillary and Bulb: Copper tubing filled with refrigerant.
    d. Suction Temperature: 40 degrees F.
    e. End Connections: Socket or flare.
    f. Working Pressure: 700 psig.
    g. Manufacturers:
        1) Henry Technologies.
        2) Parker Hannifin Corp.
        3) Danfoss Group Global.
4. Safety Relief Valve:
    a. Body and Bonnet: Ductile iron and steel, with neoprene O-ring seal.
    b. Seat Disk: Polytetrafluoroethylene.
    c. Working Pressure: 500 psig.
    d. Operating Temperature: 240 degrees F, maximum.
    e. Manufacturers:
        1) Henry Technologies.
        2) Parker Hannifin Corp.
        3) Danfoss Group Global.

D. Refer to Section 40 05 15, Piping Support Systems, for piping shields and piping support requirements.

PART 3 EXECUTION

3.01 INSTALLATION OF PIPING SYSTEM

A. Install piping products in accordance with manufacturer's written instructions, applicable requirements of ASME B31.5, ASHRAE 15, and in accordance with recognized industry practices to ensure products serve intended function.

B. Install dryers on liquid and suction lines.

C. Refrigerant Piping:

1. Cut pipe accurately to measurements established at Site and work into place without springing or forcing.
2. Install piping with sufficient flexibility to adequately provide for expansion and contraction as a result of temperature fluctuation inherent in its operation.
3. Where pipe passes through building structure, pipe joints shall not be concealed, but located where they may be readily inspected.
4. Run pipe to be insulated as shown and as required with sufficient clearance to permit application of insulation.

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5. Run piping as shown on Drawings, taking care to avoid interference with other piping, conduit or equipment. Except where specifically indicated otherwise, run piping plumb, and straight and parallel to walls and ceilings.
6. Trapping of lines shall not be permitted, except where indicated.
7. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.
8. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
9. Install piping free of sags and bends.
10. Install fittings for changes in direction and branch connections.
11. Install refrigerant piping in protective conduit where installed belowground.
12. Install accumulator in suction line near condensing unit.
13. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.
14. Slope refrigerant piping as follows:
    a. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
    b. Install horizontal suction lines with a uniform slope downward to compressor.
    c. Install traps and double risers to entrain oil in vertical runs.
    d. Liquid lines may be installed level.

D. Pipe Sleeves:

1. Provide pipe sleeves of suitable size for pipe and tubing that penetrate building structure.
2. Secure sleeves in position and location before and during construction. Space between pipe and sleeves, or between insulation and pipe sleeves, shall be not less than 1/4 inch between outside of pipe or insulation, and inside wall of sleeves.
3. Sleeves for uninsulated pipes shall have ends flush with finished wall surfaces; provide pipe or tubing as above with outside perimeter of pipe caulked to sleeve.
4. Extend sleeves for insulated pipes 1/2 inch from wall faces and caulk to sleeve on both sides.
5. Seal terminal ends of pipe insulation with mastic.
6. Extend sleeves for lines passing through floors 3 inches above finished floor slab and caulk to slab.
7. Seal penetrations through fire and smoke barriers according to Section 07 84 00, Firestopping.

E. Braze cap (seal) ends of piping when not connected to mechanical equipment.

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3.02 SOLDER JOINTS

A. Solder joints shall not be used for joining refrigerant piping systems.

3.03 BRAZED JOINTS

A. Braze copper piping with silver solder complying with AWS A5.8M/A5.8.

B. Brazed Joints:

1. Construct joints according to AWS *Brazing Handbook* Chapter “Pipe and Tube”.
2. Use Type BcuP, copper-phosphorus alloy for joining copper socket fittings with copper pipe.
3. Use Type BAg, cadmium-free silver alloy for joining copper with bronze or steel.

C. Inside of tubing and fittings shall be free of flux.

D. Clean parts to be joined with emery cloth and keep hot until solder has penetrated full depth of fitting and extra flux has been expelled.

E. Cool joints in air and remove flame marks and traces of flux.

F. During brazing operation, prevent an oxide film from forming on inside of tubing by slowly flowing dry nitrogen to expel air.

G. When brazing, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion valve bulb.

3.04 PIPE HANGERS

A. Refer to Section 40 05 15, Piping Support Systems, for piping shields and piping support requirements.

3.05 EQUIPMENT CONNECTIONS

A. Connect refrigerant piping to mechanical equipment in the manner shown, and comply with equipment manufacturer’s instructions where not otherwise indicated.

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3.06 FIELD QUALITY CONTROL

A. General:

1. Notify Engineer at least 48 hours before testing is performed.
2. Furnish equipment required for tests.
3. Group as many systems together as possible when testing in order to consolidate number of test inspections.

B. Leak Test:

1. Prior to initial operation, clean and test refrigerant piping in accordance with ASME B31.5.
2. Perform initial test with dry nitrogen to 300 psig minimum using soap solution to test joints.
3. Evacuate system after initial test and charge system with refrigerant or dry nitrogen, 20 percent refrigeration mixture to 600 psig minimum.
4. Upon completion of initial system test, test factory, as well as field, refrigerant piping joints with electronic-type leak detector to acquire a leak-tight refrigerant system.
    a. If leaks are detected, remove entire refrigerant charge for the system, replace defective pipe or fitting, and retest entire system as specified above.

C. Evacuation, Dehydration, and Charging:

1. After system is found to be without leaks, evacuate system using reliable gauge and vacuum pump capable of pulling a vacuum of at least 1-mm Hg absolute (29.88-inch Hg gage).
2. Evacuate system with vacuum pump until temperature of 35 degrees F (2 degrees C) is indicated on vacuum dehydration indicator.
3. During evacuation, apply heat to pockets, elbows, and low spots in piping.
4. Maintain vacuum on system for minimum of 12 hours after closing valve between vacuum pump and system. If system holds vacuum for 12 hours it is ready for charging.
5. Break vacuum with refrigerant gas or dry nitrogen gas, allowing pressure to build up to 2 psi (15 kPa).
6. Install new filter-dryer core in charging line.
7. Repeat evacuation procedure and complete charging of system; provide full operating charge.

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3.07 ADJUSTING

A. General:

1. Adjust thermostatic expansion valve to obtain proper evaporator superheat.
2. Adjust high-pressure and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.
3. Adjust setpoint temperature of air-conditioning or chilled-water controllers to system design temperature.
4. Perform following adjustments according to manufacturer's written instructions before operating refrigeration system:
    a. Open shutoff valves in condenser water circuit.
    b. Verify compressor oil level is correct.
    c. Open compressor suction and discharge valves.
    d. Open refrigerant valves, except bypass valves that are used for other purposes.
    e. Check open compressor-motor alignment and verify lubrication for motors and bearings.

B. Replace core of replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.

END OF SECTION

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SECTION 23 31 13
METAL DUCTS AND ACCESSORIES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Air Movement and Control Association (AMCA): 500, Test Methods for Louvers, Dampers and Shutters.
2. American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) Handbook.
3. American Society of Mechanical Engineers (ASME): A13.1, Scheme for the Identification of Piping Systems.
4. Association of the Nonwoven Fabrics Industry (INDA): IST 80.6, Water Resistance (Hydrostatic Pressure).
5. ASTM International (ASTM):
    a. A36/A36M, Standard Specification for Carbon Structural Steel.
    b. A90/A90M, Standard Test Method for Weight (Mass) of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings.
    c. A167, Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
    d. A176, Standard Specification for Stainless and Heat-Resisting Chromium Steel Plate, Sheet, and Strip.
    e. A240/A240M, Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
    f. A480/A480M, Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet and Strip.
    g. A568/A568M, Standard Specification for Steel, Sheet, Carbon, Structural, and High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled, General Requirements for.
    h. A653/A653M, Standard Specifications for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
    i. A700, Standard Practices for Packaging, Marking, and Loading Methods for Steel Products for Shipment.
    j. A924/A924M, Specification for General Requirements for Sheet Steel, Metallic-Coated by the Hot-Dip Process.
    k. A1008/A1008M, Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardenable.

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l. A1011/A1011M, Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High- Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength.
m. B209, Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
n. C423, Standard Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method.
o. C916, Standard Specification for Adhesives for Duct Thermal Insulation.
p. C1071, Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material).
q. C1139, Standard Specification for Fibrous Glass Thermal Insulation for Sound Absorbing Blanket and Board for Military Applications.
r. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
s. E96/E96M, Standard Test Methods for Water Vapor Transmission of Materials.

6. National Air Duct Cleaners Association (NADCA): General Specifications for the Cleaning of Commercial Heating, Ventilation and Air Conditioning Systems.
7. National Fire Protection Association (NFPA):
   a. 90A, Standard for the Installation of Air-Conditioning and Ventilating Systems.
   b. 90B Standard for the Installation of Warm Air Heating and Air-Conditioning Systems.
   c. 96, Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations.
   d. 255, Standard Method of Test of Surface Burning Characteristics of Building Materials.
   e. 259, Standard Test Method for Potential Heat of Building Materials.
   f. 701, Standard Methods of Fire Tests for Flame Propagation of Textiles and Films.
8. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA):
   a. Duct Construction Standards.
   b. Guidelines for Seismic Restraints of Mechanical Systems.
   c. Fibrous Glass Duct Construction Standards.
   d. Fire, Smoke, and Radiation Damper Installation Guide for HVAC Systems.
   e. HVAC Air Duct Leakage Test Manual.

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9. Underwriters Laboratories Inc. (UL):
    a. 181, Standard for Safety Factory-Made Air Ducts and Connectors.
    b. 214, Standard for Tests for Flame-Propagation of Fabrics and Films.
    c. 555, Standard for Safety Fire Dampers.
    d. 555S, Standard for Safety Smoke Dampers.

1.02 DEFINITIONS

A. The following is a list of abbreviations which may be used in this section:

1. CFM: cubic feet per minute.
2. FPM: feet per minute.
3. PCF: pounds per cubic foot.
4. WC: water column.

B. Sealing Requirements: For the purpose of duct systems sealing requirements specified in this section, the following definitions apply:

1. Seams: Joining of two longitudinally (in direction of airflow) oriented edges of duct surface material occurring between two joints. All other duct surface connections made on perimeter are deemed to be joints.
2. Joints, duct surface connections including:
    a. Girth joints.
    b. Branch and subbranch intersections.
    c. Duct collar tap-ins.
    d. Fitting subsections.
    e. Louver and air terminal connections to ducts.
    f. Access door, and access panel frames and jambs.
    g. Duct, plenum, and casing abutments to building structures.

1.03 SUBMITTALS

A. Action Submittals:

1. Product Data:
    a. Rectangular and Rigid Round Ductwork:
        1) Schedules of duct systems, materials, joints, sealing, gage and reinforcement.
        2) SMACNA Figure Numbers for each shop fabricated item.
        3) Reinforcing details and spacing.
        4) Seam and joint construction details.
        5) Hangers and supports, including methods for building attachment, vibration isolation, and duct attachment.
    b. Ductwork Accessories:
        1) Manufacturer’s product data including catalog sheets, diagrams, standard schematic drawings, installation

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instructions and details, details of materials, construction, dimensions of individual components, and finishes, including the following items:

a) Fittings and volume control damper installation (both manual and automatic) details.
b) Duct liner.
c) Sealing materials.
d) Dampers; include leakage, pressure drop, and maximum back pressure data.
e) Duct-mounted access panels and doors.
f) Flexible ducts.
g) Sheet metal fasteners.

B. Informational Submittals:

1. Seismic anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Component and attachment testing seismic certificate of compliance as required by Section 01 45 33, Special Inspection and Testing.
3. Sound Attenuators Certified Test Data:
   a. Dynamic insertion loss.
   b. Self-noise power levels.
   c. Static pressure loss.
   d. Dimensions and weights.
4. Record Drawings: Include duct systems routing, fittings details, and installed accessories and devices.

1.04 QUALITY ASSURANCE

A. Industry Standards:

1. Unless otherwise indicated or specified, sheet metal ductwork shall be constructed and installed in accordance with SMACNA Duct Construction Standards relevant to ductwork system being provided. These standards are herein referenced as the SMACNA Manual, unless otherwise indicated.
2. Comply with ASHRAE Fundamentals Handbook recommendations, except as otherwise indicated.
3. NFPA Compliance: NFPA 90A and NFPA 90B.

B. Manufacturers: Firms regularly engaged in manufacture of ductwork products of types, materials, and sizes required, whose products have been satisfactorily used in similar service for not less than 5 years.

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C. Suppliers of duct and fitting components shall provide on request the following information:

1. Laboratory performance data for duct, including leakage rate, bursting strength, collapse strength, seam strength, and pressure loss.
2. Laboratory performance data for fittings, including zero-length dynamic losses.

D. Installer shall be a firm with at least 3 years' experience of successful installation on ductwork systems similar to that required for this Project.

E. Changes or alterations to layout or configuration of duct system shall be:

1. Specifically approved in writing by Engineer.
2. Proposed layout shall provide original design results, without increasing system total pressure.

1.05 EXTRA MATERIALS

A. Furnish, tag, and box for shipment and storage the following spare parts and special tools.

Item	Quantity
Fusible Links	1 Fusible Link per Fire Damper
Special tools required to maintain or dismantle	One complete set for each different size unit

B. Delivery: In accordance with Section 01 61 00, Common Product Requirements.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Protect ductwork from dirt, water, and debris. During storage on Job Site, keep ends of ductwork covered to prevent foreign objects and water from entering ductwork.

B. If fabricated sound-lined ductwork gets wet during installation, remove and dispose of ductwork from the Site.

C. Deliver sealant materials to Site in original unopened containers labeled with manufacturer, product name and designation, color, expiration period for use, pot life, curing time, and mixing instructions for multi-component materials.

D. Store and handle sealant materials in compliance with manufacturers' recommendations to prevent deterioration or damage due to moisture, high or low temperatures, contaminants, or other causes.

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E. Deliver and store stainless steel sheets with mill-applied adhesive protective paper, maintained through fabrication and installation.

PART 2 PRODUCTS

2.01 SCHEDULES

A. Ductwork Schedule: Refer to Drawings.

2.02 GENERAL

A. Specified components of this ductwork system, including facings, mastics, and adhesives, shall have fire hazard rating not to exceed 25 for flame spread without evidence of continued progressive combustion, and 50 for smoke developed, as per test conducted in accordance with ASTM E84 and NFPA 255 methods.

B. Internally Lined Ductwork: Duct sizes indicated for internally lined ducts are the clear inside dimensions, and shall be increased in both dimensions by twice the thickness of the liner.

C. Ductwork thinner than 26-gauge will not be allowed.

D. Ductwork Interior Surfaces:

1. Smooth.
2. No sheet metal parts, tabs, angles, or other items may project into air ducts, unless otherwise specified.
3. Seams and joints shall be external.
4. For ductwork that is required to be reinforced, use only external reinforcing.

2.03 SHEET METAL MATERIALS

A. Construct metal duct systems from materials as indicated in Article, Ductwork Schedule.

B. Where no specific ductwork materials are indicated in Specifications or on Drawings, Aluminum shall be basis of Contract.

C. Galvanized Steel Ductwork:

1. Comply with ASTM A653/A653M and ASTM A924/924M.
2. Product Name: Steel Sheet, Zinc Coated (Galvanized Steel).
3. Sheet Designation: CS Type B.
4. Applicable Specification: ASTM A653/A653M.
5. (Zinc) Coating Designation: G90.

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6. Coating designation in accordance with Test Method A, ASTM A90/A90M. and ASTM A924/A924M.
7. Provide mill-phosphatized finish for ducts exposed to view and for ducts scheduled to be painted.
8. Provide sheet metal packaged and marked as specified in ASTM A700.

D. Aluminum Ductwork:

1. Comply with ASTM B209.
2. Aluminum Sheet: Alloy 3003-H14, unless indicated otherwise.
3. Aluminum Connectors and Bar Stock: Alloy 6061-T6 or equivalent.

E. Stainless Steel Ductwork:

1. Comply with ASTM A167, ASTM A176, ASTM A240/A240M, and ASTM A480/A480M.
2. Stainless Steel Sheet: Type 304, unless indicated otherwise.
3. Gauge shall comply with SMACNA manual, unless specified otherwise.
4. Finish: No. 2 B (cold-rolled, bright) finish, except as otherwise noted.
5. With No. 4 finish on exposed surface for ducts exposed to view.

F. Exposed Ductwork: Where ductwork is indicated to be exposed to view in occupied spaces, provide materials which are free from visual imperfections including pitting, seam marks, roller marks, oil canning, stains, discoloration, and other imperfections, including those which would impair painting.

G. Reinforcement Shapes and Plates: Unless otherwise indicated, provide reinforcements of same material as ductwork.

2.04 DUCT SEALING MATERIALS

A. General: The term sealant used here is not limited to materials of adhesive or mastic nature, but also includes tapes and combinations of open weave fabric strips and mastics.

B. Adhesives, Cements, Sealant, and Installation Accessories: As recommended by duct manufacturer for application.

C. Solvent-Based Sealants:

1. Ultraviolet light resistant.
2. Mildew resistant.
3. Flashpoint: Greater than 70 degrees F, SETA CC.
4. Manufacturers and Products:
    a. Hardcast, Inc.; Versagrip 102.
    b. Rectorseal; AT-33.
    c. Childers CP-140.

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2.05 FIRESTOPPING

A. Refer to Section 07 84 00, Firestopping.

2.06 DUCTWORK FASTENERS

A. General:

1. Rivets, bolts, or sheet metal screws.
2. Ductwork fasteners shall be same metal as duct being supported, unless otherwise noted.

B. Self-Drilling Screws:

1. Galvanized Steel Ductwork System: Sheet metal screws shall be hex washer head (HWH) TEKS® self-drilling type, formed from heat-treated carbon steel with zinc electroplated finish.
2. Aluminum Ductwork System:
   a. Sheet metal screws shall be hex washer head (HWH) TEKS® self-drilling type, formed from heat-treated complete with bonded metal and fiber washer for dielectric separation.
   b. Manufacturers:
      1) DB Building Fasteners Inc., Santa Fe Springs, CA.
      2) Clark Craft Fasteners, Tonawanda, NY.
3. Stainless Steel Ductwork System:
   a. Sheet metal screws shall be hex washer head (HWH) TEKS® self-drilling type, formed from heat-treated Marutex® stainless steel with strength of Type 410 stainless steel and corrosion resistance of Type 304 stainless steel.
   b. Manufacturers:
      1) DB Building Fasteners Inc., Santa Fe Springs, CA.
      2) Clark Craft Fasteners, Tonawanda, NY.

2.07 DUCTWORK PRESSURE CLASS

A. Construct duct systems to pressure classifications indicated as follows:

1. Supply Ducts: 3-inch WC.
2. Return Ducts: 2-inch WC, negative pressure.
3. Exhaust Ducts: 2-inch WC, negative pressure.

B. Where no specific duct pressure designations are indicated in Specifications or on Drawings, 2-inch WC pressure class shall be basis of Contract.

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2.08 RECTANGULAR DUCTWORK

A. Fabricate rectangular ducts in accordance with SMACNA Rectangular Industrial Duct Construction Standards, unless specified otherwise.

B. Crossbreaking or Cross Beading: Crossbreak or bead duct sides that are 19 inches and larger and are 20-gauge or less, with more than 10 square feet of unbraced panel area, as indicated in SMACNA Manual, unless they are lined or are externally insulated.

C. Air Handling Unit Discharge Ductwork: Ductwork extending from variable air volume air handling units up to and including first elbow or terminal tap outside air handling unit room shall be constructed of 16-gauge, minimum sheet metal, same material as remainder of system. As specified on Drawings.

2.09 RECTANGULAR DUCTWORK FITTINGS

A. Fabricate elbows, transitions, offsets, branch connections, and other duct construction in accordance with SMACNA Rectangular Industrial Duct Construction Standards.

B. Elbows:

1. Fit square-turn elbows with vane side rails.
2. Shop fabricate double-blade turning vanes of same material as ductwork.
3. Fabricate with equal inlet and outlet.
4. Rectangular radius elbows with inside radius of 3/4 of duct width in direction of turn.
5. Manufacturers and Products:
    a. Elgen; All-Tight.
    b. Duro-Dyne; Type TR.

2.10 RECTANGULAR DUCTWORK BRANCH CONNECTIONS

A. Branch duct connections to rectangular duct mains shall be made using factory fabricated fittings with spot welded tap to main duct connections or with factory fabricated, field installed taps, with spin-in or mechanical fastened tap to main duct connections.

2.11 RECTANGULAR DUCTWORK INSULATION LINER

A. Location: Provide ductwork with internal insulation liner where indicated on Drawings or in Ductwork Schedule.

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B. Material:

1. Fiberglass, nominal 1.5 pcf density liner, K factor 0.25 maximum at 75 degrees F mean.
2. Black composite coating on surface exposed to airstream to prevent erosion of glass fibers, for temperatures to 250 degrees F.
3. Liquid water repellency rating not less than 4.0 when tested in accordance with INDA IST 80.6.
4. Potential heat value not exceeding 3,500 Btu per hour per pound when tested in accordance with NFPA 259 and meeting classification of "Limited Combustible" as defined by NFPA 90A.
5. Maximum rated velocity not less than 6,000 fpm when tested in accordance with ASTM C1071.
6. Resistant to microbial growth using a "no growth criteria" when tested in accordance with ASTM C1139.
7. Manufacturers and Products:
   a. CertainTeed; Toughgard.
   b. JohnsManville; Linacoustic RC.
   c. Knauf; Duct Liner M.

C. Thickness: See Section 23 07 00, HVAC Insulation.

D. Liner Adhesive: In accordance with NFPA 90A and ASTM C916.

E. Mechanical Fasteners:

1. Same material as ductwork, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct.
2. Provide fasteners that do not damage liner when applied as recommended by manufacturer, that do not cause leakage in duct, and will indefinitely sustain 50-pound tensile dead load test perpendicular to duct wall.
3. Fastener Pin Length: As required for thickness of insulation and without projecting more than 1/8 inch into airstream.
4. Adhesive for Attachment of Mechanical Fasteners: In accordance with Fire Hazard Classification of duct liner system.

F. Liner Application:

1. Ductwork liner shall be applied at time of ductwork manufacture in an approved sheet metal workshop.
2. Adhere single layer of indicated thickness of duct liner with 90 percent coverage of adhesive at liner contact surface area. Multiple layers of insulation to achieve indicated thickness is prohibited.
3. Apply coat of adhesive to liner facing in direction of airflow not receiving metal nosing.
4. Butt transverse joints without gaps and coat joint with adhesive.

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5. Fold and compress liner in corners of rectangular ducts or cut and fit to assure butted edge overlapping.
6. Longitudinal Joints:
    a. Shall not occur except at corners of ducts, unless size of duct and standard liner product dimensions make longitudinal joints necessary.
    b. Apply adhesive coating on longitudinal seams in ducts exceeding 2,500 fpm air velocity.
7. Secure liner with mechanical fasteners 4 inches from corners and at intervals not exceeding 12 inches transversely around perimeter, at 3 inches from transverse joints, and at intervals not exceeding 18 inches longitudinally.
8. Secure transversely oriented liner edges facing airstream with metal nosing that are either channel or “Z” profile or are integrally formed from duct wall at the following locations:
    a. Fan discharge.
    b. Intervals of lined duct preceding unlined duct.
    c. Upstream edges of transverse joints in ducts.
9. Seal insulation edges.
10. Repair abrasions or tears with mastic.

2.12 DOUBLE WALL DUCTWORK

A. General:

1. Double wall duct system consisting of outer sheet metal pressure shell, internal sheet metal liner, with insulating material in annular space.
2. Location: Provide where indicated on Drawings or in Ductwork Schedule.

B. Construction:

1. Outer shell gauge shall be based upon actual outer shell dimensions.
2. Inner liner secured to outer shell with mechanical fasteners that maintain metal liner distance from duct without compressing insulation.
3. Inner liner:
    a. Solid sheet metal liner, with no insulation liner exposed to airstream, unless indicated to be perforated.
    b. Same material as outer pressure shell, unless indicated otherwise.

C. Insulation:

1. Void space between liner and outer pressure shell shall be filled with fiberglass insulation, material and installation in accordance with Article Rectangular Ductwork Insulation Liner.
2. Thickness: Minimum 1 inch or greater thickness where indicated on Drawings or Ductwork Schedule.]

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3. R-Value: Minimum 4.2 hours foot squared degrees F per Btu or greater, where indicated on Drawings or Ductwork Schedule.

D. Liner Termination:

1. Terminate internal liner with duct build-outs (metal hat sections) where double wall ductwork connects to single wall ductwork or to any uninsulated component.
2. Secure build-outs to duct wall with bolts, screws, rivets, or welds.
3. Terminate liner at fire dampers at connection to fire damper sleeve.

2.13 RIGID ROUND DUCTWORK

A. Construct rigid round ducts in accordance with SMACNA Round Industrial Duct Construction Standards, unless specified otherwise.

B. Basic Round Diameter: As used in this Article, is inside diameter of size of round duct.

C. Where space limitations prevent use of round duct or where shown on Drawings, provide ductwork of flat oval construction hydraulically equivalent to round ductwork.

D. Fabricate round ducts with spiral seam construction, except where diameters exceed 72 inches. Fabricate ducts having diameters greater than 72 inches with longitudinal butt-welded seams.

E. Ductwork seams of Snaplock type shall not be used.

2.14 RIGID ROUND DUCTWORK FITTINGS

A. Construct rigid round ductwork fittings in accordance with SMACNA Round Industrial Duct Construction Standards, unless otherwise specified.

B. 90-Degree Tees, Laterals, and Conical Tees: Fabricate to conform to SMACNA manual with metal thicknesses specified for longitudinal seam straight duct.

C. Diverging Flow Fittings: Fabricate with a reduced entrance to branch taps with no excess material projecting from body onto branch tap entrance.

D. Elbows:

1. Fabricate in stamped (die-formed), pleated, or segmented (gored) construction 1.5 times elbow diameter. Two piece segment elbows are not allowed, except with turning vanes.
2. Segmented Elbows: Fabricate with welded construction.

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3. Round Elbows 8 Inches and Smaller:
    a. Stamped elbows for 45- and 90-degree elbows and pleated elbows for 30, 45, 60, and 90 degrees configuration.
    b. Fabricate nonstandard bend angle configurations or nonstandard sized (for example, 3-1/2 inches and 4-1/2 inches) elbows with segmented construction.
4. Round Elbows 9 Inches Through 14 Inches:
    a. Segmented or pleated elbows for 30, 45, 60, and 90 degrees.
    b. Fabricate nonstandard bend angle configurations or nonstandard sized (for example, 9-1/2 inches and 10-1/2 inches) elbows with segmented construction.

2.15 ROUND DUCTWORK BRANCH CONNECTIONS

A. Branch duct connections (taps) to round duct mains shall be made using factory fabricated fittings.

B. Field installed taps are not acceptable.

2.16 ROUND DUCTWORK INSULATION LINER

A. Location: Provide round ductwork with internal insulation liner where indicated on Drawings or in Ductwork Schedule.

B. Material:

1. Fiberglass, nominal 4.0-pcf density, K factor 0.23 maximum at 75 degrees F mean.
2. Black composite coating on surface exposed to air stream, to prevent erosion of glass fibers.
3. Suitable for temperatures up to 250 degrees F.
4. Noise Reduction Coefficient: Minimum 0.75 for 1.0-inch thickness, in accordance with ASTM C423.
5. Liquid water repellency rating not less than 4.0 when tested in accordance with INDA IST 80.6.
6. Potential heat value not exceeding 3,500 Btu per hour per pound when tested in accordance with NFPA 259 and meeting classification of “Limited Combustible” as defined by NFPA 90A.
7. Maximum rated velocity not less than 6,000 fpm when tested in accordance with ASTM C1071.
8. Resistant to microbial growth using a “no growth criteria” when tested in accordance with ASTM C1139.
9. Manufacturers and Products:
    a. CertainTeed.
    b. Johns Manville; Spiracoustic Plus.
    c. Knauf.

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C. Thickness: Minimum 1.0 inch(es) or greater thickness where indicated on Drawings or Ductwork Schedule.

D. R-Value: Minimum 4.3 hour foot squared degrees F per Btu, or greater, where indicated on Drawings or Ductwork Schedule.

E. Liner Application:

1. Install liner in accordance with manufacturer's instructions.
2. In Straight Duct Sections: Apply at time of ductwork manufacture in an approved sheet metal workshop, or field install.
3. In Duct Fittings: Apply at time of ductwork manufacture in an approved sheet metal workshop only.
4. Install single layer of indicated thickness of duct liner. Multiple layers of insulation to achieve indicated thickness is prohibited.
5. Fastening: Interference fit.
6. Seal insulation edges.
7. Repair abrasions or tears with mastic.

2.17 INSULATED FLEXIBLE DUCT

A. Fabricate in accordance with:

1. UL 181, Class 1.
2. NFPA 90A and NFPA 90B.

B. Construction:

1. Outer Jacket: Fire retardant reinforced metalized vapor barrier jacket with reinforced cross-hatched scrim having a permeance of not greater than 0.1 perm when tested in accordance with ASTM E96/E96M, Procedure A.
2. Inner Liner: Tri-laminate of aluminum foil, fiberglass, and aluminized polyester.
3. Reinforcing: Galvanized steel wire helix, mechanically locked to and encapsulated by inner liner fabric.
4. Insulation:
   a. Factory insulated with fiberglass insulation.
   b. R-value: 6.0 minimum at a mean temperature of 75 degrees F.
5. Internal Working Pressure: Rating shall be minimum 4-inch WC positive and 5-inch WC negative, with bursting pressure of at least 2-1/2 times working pressure.
6. Air Velocity Rating: 4,000 fpm, minimum.

C. Environment: Suitable for continuous operation at temperature range of minus 20 degrees F to plus 200 degrees F.

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D. Manufacturers and Products:

1. Flex-Master; Type 5M.
2. Thermaflex; Type M-KC.
3. Hart & Cooley; Type F216.

2.18 DUCTWORK HANGERS AND SUPPORTS

A. General:

1. Attachments, hangers, and supports for ductwork shall be in accordance with SMACNA Manual referenced for type of duct system being installed.
2. Duct hanging system shall be composed of three elements; upper attachment to building, hanger itself, and lower attachment to duct.
3. Wire hangers are not acceptable.
4. Hanger Spacing:
   a. Ducts Up to 60 inches in Largest Dimension: 10 feet, maximum.
   b. Ducts Over 61 inches in Largest Dimension: 8 feet, maximum.

B. Construction Materials: Supporting devices including, but not limited to, angles used for support and bracing, baseplates, rods, hangers, straps, screws, bolts shall be as follows:

1. Galvanized Steel Ductwork:
   a. Indoors: Carbon steel, zinc electroplated.
   b. Outdoors: Carbon steel, hot-dipped galvanized after fabrication.
2. Aluminum Ductwork Indoors and Outdoors:
   a. Carbon steel, hot-dipped galvanized after fabrication.
   b. Non-metallic pad between lower attachment and ductwork, to achieve dielectric separation.
3. Stainless Steel Ductwork Indoor and Outdoors: Stainless steel, same ASTM Grade as ductwork.

C. Building Attachments:

1. Concrete inserts, powder-actuated fasteners, or structural steel fasteners appropriate for building materials.
2. Do not use powder-actuated concrete fasteners for lightweight aggregate concrete or for slabs less than 4 inches thick.
3. Upper Attachment (Concrete):
   a. Drive pin fastener and expansion nail anchor may be used for ducts up to 18-inch maximum dimension.
   b. Threaded stud fastener may be used for ducts up to 36-inch maximum dimension.
   c. Concrete attachments shall be made of steel.

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D. Duct Fasteners: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials and conforming to requirements of Article Ductwork Fasteners.

E. Trapeze and Riser Supports: Steel shapes conforming to ASTM A36/A36M, hot-dipped galvanized after fabrication.

2.19 DUCTWORK FLEXIBLE CONNECTIONS

A. General:

1. Factory fabricated metal-edged fabric flexible connectors for commercial or industrial applications.
2. Sheet metal permanently secured to fabric with double fabric fold, double metal crimp.
3. Comply with NFPA 90A and NFPA 90B requirements.
4. Airtight and waterproof.

B. Materials:

1. Flame-retarded or noncombustible fabrics, coatings, and adhesives complying with UL 181, Class 1.
2. Metal Edges: Construct from same material as ductwork, unless otherwise noted.
3. Fabric:
    a. Comply with NFPA 701 or UL 214 (except teflon coated).
    b. Woven polyester or nylon for most applications.
    c. Woven fiberglass for high temperature applications.
    d. Coating: Vinyl.

C. Construction:

1. Fold and crimp metal edge strips onto fabric as illustrated in SMACNA Manual.
2. Standard Metal Edged Connectors: Strip of fabric 3 inches wide attached to two strips of 3-inch-wide sheet metal.
3. Wide Metal Edged Connectors: Strip of fabric 4 inches wide attached to two strips of 4-inch-wide sheet metal.
4. Extra Wide Metal Edged Connectors: Strip of fabric 6 inches wide attached to two strips of 6-inch-wide sheet metal.

D. Manufacturers:

1. Ductmate; PROflex, Commercial.
2. Ventfabrics.
3. Duro-Dyne.

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2.20 CEILING ACCESS DOORS

A. As specified in Section 08 30 00, Specialty Doors.

B. Size: 30 inches by 30 inches.

C. Finish in primer finish suitable for field painting.

D. Manufacturers:

1. Inryco Milcor.
2. Krueger.

2.21 DUCT INSPECTION DOORS

A. General:

1. Insulated, gasketed, and at least 15 inches by 15 inches when duct dimensions are large enough.
2. On ductwork where largest side dimension is less then 16 inches, furnish inspection doors at least 8 inches by 8 inches.
3. Complete with necessary hardware and either Amerlock 10 or Ventlock No. 100 latches, and Ventlock Series No. 100 hinges.
4. Fabricated of same material as ductwork.

B. Round Spin-in Type Access Doors:

1. Size: 18-inch and 24-inch diameter will be acceptable in lieu of comparable size square or rectangular access doors specified herein.
2. Complete with insulation, spin-in frame, inner door, attachment cable, gaskets, three latches, and pull ring.
3. Manufacturer and Product: Flexmaster; Inspector Series.

C. Casing and Plenum Access Doors:

1. Size: 57 inches high by 24 inches wide minimum where possible.
2. Complete with hardware, hinges, seals, and latch handles.
3. Doors and frames shall be designed to close with pressure.
4. Latch Handles: Ventlock, Series No. 260.
5. Hinges: Ventlock, Series No. 200 and No. 300.

D. Manufacturers:

1. Ventlok.
2. Duro-Dyne.
3. Flexmaster.

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2.22 MANUAL DAMPERS

A. Butterfly Manual Dampers:

1. Fabricate from two gauges heavier than duct in which installed, of same material as ductwork.
2. Align operating handle with damper blade.
3. Provide 2-inch standoff bracket for insulated duct systems.
4. Damper Manufacturers:
   a. Ruskin.
   b. American Warming and Ventilating.
5. Operator Manufacturers:
   a. Accessible Ductwork: Ventlok; Type 620 or 635.
   b. Accessible Insulated Ductwork: Ventlok; Type 639.
   c. Concealed Ductwork: Ventlok; Type 677 with extended operating rod and concealed regulator with plain cover.

2.23 BACK DRAFT DAMPERS

A. General: Damper pressure drop ratings shall be based on tests and procedures performed in accordance with AMCA 500.

B. Steel Frame, Nonmetallic Blades:

1. Fabrication:
   a. Frame: 2 inches by minimum 18-gauge (51 mm by minimum 1.6 mm) galvanized steel with windstops to reduce backflow.
   b. Blades:
      1) Style: Single piece, independent.
      2) Action: Parallel.
      3) Material: Noncombustible, neoprene coated fiberglass.
      4) Orientation: Horizontal.
      5) Width: Maximum 6 inches (152 mm).
   c. Rear Bird Screen: Galvanized expanded metal.
   d. Mounting:
      1) Suitable for mounting in vertical or horizontal airflow up positions.
      2) Configured for positions as shown on Drawings.
   e. Finish: Factory applied air-dried epoxy paint on steel damper parts.
2. Performance Data:
   a. Temperature Rating: Withstand minus 30 degrees to 200 degrees F (minus 34 degrees to 93 degrees C).
   b. Maximum Back Pressure: 4-inch WC (1.0 kPa).
   c. Maximum System Air Velocity: 1,000 fpm (5.1 m/s).
   d. Maximum Spot Air Velocity: 1,200 fpm (6.1 m/s).

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3. Accessories:
    a. Duct Transition Connection: Round. Oval. Rectangular.
    b. Screen:
        1) Type: Bird.
        2) Location: Front with sleeve.
        3) Material: Aluminum.
4. Manufacturers and Products:
    a. Ruskin; Model NMS2.
    b. Vent Products, Co.

C. Aluminum, Counterbalanced, Standard Duty:

1. Fabrication:
    a. Frame: 2 inches by minimum 0.06 inch (51 mm by minimum 1.5 mm), 6063-T5 extruded aluminum channel with front flange and rear flange and mitered corners.
    b. Blades:
        1) Style: Single piece, overlap frame.
        2) Action: Parallel.
        3) Material: Minimum 0.025-inch (0.6 mm) 6063-T5 formed aluminum.
        4) Width: Maximum 6 inches (152 mm).
    c. Bearings: Corrosion-resistant, long-life, synthetic, formed as single piece with axles.
    d. Blade Seals: Extruded vinyl, mechanically attached to blade edge.
    e. Linkage: Concealed in frame.
    f. Axles: Corrosion-resistant, long-life, synthetic, locked to blade and formed as single piece with bearings.
    g. Counterbalances: Adjustable zinc plated steel weights mechanically attached to blade enabling damper to operate over wide range of pressures.
    h. Mounting:
        1) Suitable for mounting in vertical, horizontal airflow up, and horizontal airflow down positions.
        2) Configured for positions as shown on Drawings.
    i. Finish: Factory applied air-dried epoxy paint on all damper parts.
2. Performance Data:
    a. Temperature Rating: Withstand minus 40 degrees to 200 degrees F (minus 40 degrees to 93 degrees C).
    b. Maximum Back Pressure: 2-inch WC (500 Pa).
    c. Maximum Spot Air Velocity: 1,000 fpm (5 mps).
    d. Operation of Blades:
        1) Start to Open: 0.01-inch WC (0.002 kPa).
        2) Fully Open: 0.06-inch WC (0.01 kPa).

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e. Pressure Drop: Maximum 0.04-inch WC (0.01 kPa) at 1,000 fpm (305 mpm) through 24-inch by 24-inch (610 mm by 610 mm) damper.

3. Accessories:
   a. Duct Transition Connection: Round. Rectangular.
   b. Screen:
      1) Type: Bird.
      2) Location: Front with sleeve.
      3) Material: Aluminum.
4. Manufacturers and Products:
   a. Ruskin; Model CBD2.
   b. Greenheck; Series 160, 360, 460.

2.24 FIRE, FIRE/SMOKE DAMPERS

A. Duct Mounted Fire Dampers in Fire Walls with Rating of 2 Hours or Less:

1. NFPA 90A rated for 1-1/2-hour service.
2. Blades, frame, and mounting angles same material as ductwork.
3. Accordion style folded blades. 165 degrees F fusible link.
4. Approved for installation with 2-hour fire rating.
5. Rated, manufactured, tested, and approved in accordance with UL 555.
6. Blades out of airstream when open (Style B).
7. Furnish with sleeved frame for duct connections.
8. Labeled for use in **[E: static] [F: dynamic]** mode.
9. Furnish dynamic and horizontal mounted dampers with springs for proper closure.
10. Corrosive Service Dampers: Type 316 stainless steel.
11. Manufacturers and Products:
    a. Nailor Industries; Model 0130, Type B.
    b. Ruskin; (D)IBD20, Type B.

B. Combination Fire/Smoke Dampers:

1. General:
   a. UL Listed according to UL 555S.
   b. UL Listed for 1-1/2 hour rating according to UL 555.
   c. As part of UL qualification, smoke dampers shall have demonstrated capacity to operate (to open and close) under HVAC system operating conditions, with pressures up to 4-inch WC in closed position, and 2,000-fpm air velocity in open position.
2. Fusible Link: Replaceable, 165 degrees F.
3. Bearings: Stainless steel sleeve turning in extruded hole in frame. Galvanized bearings are not acceptable.

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4. Controlled Closure: Heat-actuated release device to prevent duct and HVAC component damage. Instantaneous damper closure is unacceptable.
5. Leakage Class: In accordance with UL 555S Class I (4 cfm per square foot at 1-inch WC).
6. Damper Actuator: UL 555S, suitable for **[E: 120V ac] [F: 24V ac]** power supply.
7. Frame and Blades: 16-gauge galvanized steel.
8. Mounting Sleeve: Factory installed, 18-gauge galvanized steel, length to suit wall or floor application.
9. Manufacturer and Product: Ruskin; FSD Series.

2.25 CONTROL DAMPERS

A. Refer Section 23 09 13, HVAC Controls, Field Components, and Instruments, for requirements.

2.26 EXTERNAL DUCT INSULATION

A. Refer to Section 23 07 00, HVAC Insulation.

2.27 MISCELLANEOUS ACCESSORIES

A. Prefabricated Roof Curb:

1. Refer to Section 07 70 01, Roof Specialties and Accessories.
2. Prefabricated roof curbs, flashing and counterflashing shall be constructed of minimum 0.08-inch aluminum.
3. Internal Insulation:
   a. Minimum of 1-1/2-inch-thick, 1-pound density, glass fiber insulation.
   b. Seams sealed to prevent condensation.
4. Welded or tabbed and riveted construction will be acceptable. Both types of construction shall be manufactured and sealed as required to be watertight and weatherproof.
5. Lower section of roof curb that will be integrated with roofing system shall be constructed to accommodate roofing system provided including cant strip as required.
6. Top surface of curb shall have closed-cell rubber weather-seal pad. Provide wooden nailer sections as required for installation.
7. Sheet metal counterflashing shall be provided to accommodate rectangular or round ductwork.
8. Sheet metal screws and rivets shall be stainless steel or coated with corrosion-resistant material.
9. Height of roof curb shall be 12 inches, unless otherwise indicated herein or on Drawings.

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10. Length and width of roof curb shall be sized by Contractor for particular application.
11. Roof curb shall be pre-sloped to accommodate roof pitch and allow equipment to set level.
12. Manufacturer:
    a. Thycurb.
    b. Factory fabricated by equipment manufacturer.

B. Accessories Hardware:

1. Instrument Test Holes:
    a. Cast metal, material to suit duct material, including screw cap and gasket and flat mounting gasket.
    b. Size to allow insertion of pitot tube and other testing instruments.
    c. Provide in length to suit duct insulation thickness.
2. Flexible Duct Clamps:
    a. Stainless steel band with cadmium-plated hex screw to tighten band with worm-gear action.
    b. Provide in sizes from 3 inches to 18 inches to suit duct size.
3. Adhesives: High strength, quick setting, neoprene based, waterproof and resistant to gasoline, and grease.

2.28 DUCTWORK IDENTIFICATION

A. Painted Identification Materials:

1. Stencils: Standard metal stencils, prepared for required applications with letter sizes generally comply with recommendations of ASME A13.1 for piping and similar applications, but not less than 1-1/4-inch high letters for ductwork and not less than 3/4-inch-high letters for access door signs and similar operational instructions.
2. Stencil Paint: Standard exterior type stenciling enamel; black, except as otherwise indicated; either brushing grade or pressurized spray can form and grade.
3. Identification Paint: Standard identification enamel of colors indicated or in accordance with ASME A13.1 for colors for systems not identified herein.

B. Plastic Duct Markers:

1. General: Provide manufacturer’s standard laminated plastic, color coded duct markers. Conform to the following color code:
    a. Black text on yellow background: Odorous Air.
    b. White text on blue background: Services other than hazardous exhaust and odorous air.
    c. For other hazardous exhausts, use colors and designs recommended by ASME A13.1.

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C. Nomenclature: Include the following:

1. Direction of air flow.
2. Duct service (supply, return, exhaust).

D. Manufacturers:

1. W.H. Brady, Co.
2. Seton Identification Products.
3. Craftmark.
4. Brimar Industries, Inc.

2.29 PAINTING OF DUCTWORK]

A. Refer to Section 09 90 00, Painting and Coating.

PART 3 EXECUTION

3.01 GENERAL INSTALLATION

A. Miscellaneous:

1. Install sheet metal ductwork and flexible ductwork in accordance with SMACNA Manual, NFPA 90A, and NFPA 90B.
2. Install ductwork using manufacturer's recommended adhesives, cement, sealant, and insulation accessories.
3. Align ductwork accurately at connections, within 1/8-inch misalignment tolerance and with internal surfaces smooth.
4. Interface Between Ductwork and Louvers: At locations where ductwork is connected to louver for either intake or exhaust purposes, ductwork shall be installed, sloped, and connected to louver so water entering ductwork system positively drains back to and out of louver.

B. Ductwork Location:

1. Locate ductwork runs vertically and horizontally, unless otherwise indicated.
2. Avoid diagonal runs wherever possible.
3. As indicated by diagrams, details, and notations or, if not otherwise indicated, run ductwork in shortest route that does not obstruct usable space or block access for servicing building and equipment.
4. In general, install as close to bottom of structure as possible.
5. For ductwork concealed above ceiling, maximize clearance between bottom of ductwork and top of ceiling construction.
6. Hold ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

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7. Ductwork that must transition and drop below piping or other ductwork shall be transitioned back to bottom of structure immediately adjacent to obstruction.

C. Penetrations:

1. Provide duct sleeves or prepared openings for duct mains, duct branches, and ducts passing through roofs, walls and ceilings.
2. Clearances:
   a. For uninsulated ducts, allow 1-inch clearance between duct and sleeve, except at grilles, registers, and diffusers.
   b. For insulated ducts, allow 1-inch clearance between insulation and sleeve, except at grilles, registers, and diffusers.
3. Closure Collars:
   a. Minimum 4 inches wide on each side of walls or floors where sleeves or prepared openings are installed.
   b. Fit collars snugly around ducts and insulation.
   c. Same gauge and material as duct.
   d. Grind edges of collar smooth to preclude tearing or puncturing insulation covering or vapor barrier.
   e. Use fasteners with maximum 6-inch centers on collars.
4. Packing: Mineral fiber in spaces between sleeve or opening and duct or duct insulation.

D. Concealment:

1. Wherever possible in finished and occupied spaces, conceal ductwork from view by locating in mechanical shafts, hollow wall construction, or above suspended ceiling.
2. Do not encase horizontal runs in solid partitions, except as specifically shown.
3. Limit clearance to 1 inch where furring is shown for enclosure or concealment of ducts, but allow for insulation thickness, if any.

E. Coordination with Other Trades:

1. Coordinate duct installation with installation of accessories, dampers, coil frames, equipment, controls, and other associated work of ductwork system.
2. Ductwork shall be configured, positioned, and installed to permit installation of light fixtures as indicated on Drawings.
3. Coordinate ductwork layout with suspended ceiling, lighting and sprinkler head layouts and similar finished work.
4. Electrical Equipment Spaces: Do not run ductwork through transformer vaults and other electrical equipment spaces and enclosures.

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F. Shower Room and Toilet Room Exhaust Ductwork:

1. Joints and Seams: Seal watertight.
2. Slope branch ducts downward to grille.

G. Fume Hood, Laboratory, and Chlorine Room Exhaust Ductwork:

1. Seal joints and seams with chemical-resistant mastic.
2. Rivet butt joints with minimum of eight pop rivets.

3.02 RECTANGULAR DUCTWORK

A. General:

1. Where possible, install ductwork so seams and joints will not be cut for installation of grilles, registers, or ceiling outlets.
2. If cutting of seams or joints is unavoidable, reinforce cut portion to original strength.

B. Low Pressure Taps:

1. Use bell mouth or conical fittings with integral locking quadrant damper. Spin-in fitting shall be sealed at duct tap with a gasket or sealed with sealant as specified for medium pressure ductwork.
2. Determine location of spin-in after outlet location is determined.
3. Fitting shall be securely attached to shaft to prevent damper from rotating around shaft.

C. Fittings:

1. Use bell-mouth or conical tee fittings for round duct takeoffs from rectangular mains.
2. Use 45-degree entry fittings conforming to SMACNA requirements for rectangular takeoffs from rectangular or round mains.
3. Make offsets with maximum angle of 45 degrees.
4. Use fabricated fittings for changes in directions, changes in size and shape, and connections.

D. Rectangular Ductwork Transverse Joints:

1. Install each run with a minimum of joints.
2. Install couplings tight to duct wall surface with projections into duct at connections kept to a minimum.
3. Mechanical Joint Option:
    a. Construct transverse joints with Ductmate 25/35 duct connector systems, Ductmate W.D.C.I. Heavy/Lite duct connector systems, or Ductlok J/E duct connector system. Slip-on duct flange

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connectors shall have integral sealant pocket with permanently flexible sealant.

b. When using Ductmate W.D.C.I. Heavy/Lite system, construct ductwork in accordance to the Ductmate W.D.C.I. Heavy J and Light H Assembly Manual and Duct Construction Standards.

c. When using Ductlok J/E duct connector system, construct ductwork in accordance with Ductlok's Rectangular Duct Construction Manual for Low, Medium, and High Pressure.

d. For longitudinal seams, use Pittsburgh lock seam sealed internally with permanently elastic sealer such as Ductmate 5511M mastic.

e. Conform to SMACNA Class A sealing requirements.

3.03 RIGID ROUND DUCTWORK

A. General: Except where interrupted by fittings, install round ducts in lengths as long as possible to minimize joints.

B. Rigid Round Ductwork Joints:

1. Rigid round ductwork joints shall be in accordance with SMACNA HVAC Duct Construction Standards, Metal and Flexible, unless otherwise specified.
2. Single and Double Wall Supply and Return System Joints:
   a. Less than 36 Inches: Slip coupling.
   b. 36 Inches and Larger: Flanged connector, Van Stone, or welded companion flange type.
3. Single and Double Wall Exhaust and Return System Joints:
   a. Spiral Seam Duct: Welded flanged connector.
   b. Longitudinal Seam Duct: Van Stone flange connector.

3.04 INSULATED FLEXIBLE DUCT

A. Installation:

1. Where shown, between branch duct and ceiling diffusers and grilles.
2. Without sags, kinks, sharp offsets, or elbows.
3. As straight and taut as possible.

B. Connection: Connect flexible ductwork to round collars, air distribution devices, and terminal units in accordance with flexible duct manufacturer's recommendations.

C. Length: Maximum length of low-pressure flexible duct (construction pressure class up to 2-inch WC) to be 5 feet.

D. Flexible ductwork shall not pass through wall, floor, or fire resistant rated assembly.

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3.05 DUCTWORK HANGERS AND SUPPORTS

A. Install ductwork with support systems in accordance with SMACNA Manual, unless otherwise noted.

B. Support ducts rigidly with suitable ties, braces, hangers, and anchors of type, which will hold ducts true-to-shape and to prevent buckling.

C. Install additional bracing on ductwork as required, to prevent ballooning or breathing.

D. Support horizontal ducts within 2 feet of each elbow and within 4 feet of each branch intersection.

E. Support vertical ducts at maximum interval of 16 feet and at each floor.

F. Upper attachments to structures shall have allowable load not exceeding 1/4 of failure (proof test) load, but are not limited to specific methods indicated.

G. In new construction, install concrete insert prior to placing concrete.

3.06 FLEXIBLE CONNECTIONS

A. Flexible Collars and Connections:

1. Use between fans and ducts.
2. For round ducts, securely fasten flexible connections by zinc-coated steel clinch-type draw bands.
3. For rectangular ducts, lock flexible connections to metal collars.

3.07 DAMPERS

A. General:

1. Inspection:
   a. Inspect areas to receive dampers.
   b. Notify Engineer of conditions that would adversely affect installation or subsequent utilization of dampers.
   c. Do not proceed with installation until unsatisfactory conditions are corrected.
2. Install dampers at locations indicated on Drawings and in accordance with manufacturer’s installation instructions.
3. Install square and level.
4. Handle damper using sleeve or frame. Do not lift damper using blades or jack-shaft.
5. Damper blades and hardware shall operate freely without obstruction.

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6. Damper blades and hardware that bind within frame or obstructed by adjacent construction will not be acceptable.
7. When installed, damper frames shall be gasketed or caulked to eliminate leakage between duct and damper frames.
8. Head and sill shall have stops.
9. Suitable for installation in mounting arrangement shown.
10. Do not compress or stretch damper frame into duct or opening.

B. Manual Dampers:

1. Provide balancing dampers for grilles and diffusers as indicated on Drawings and in every branch duct as near main as possible.
2. Add or remove balancing dampers as requested by air balancing firm for necessary control of air.

C. Back Draft Dampers:

1. Install dampers square and free from racking with blades running horizontally.
2. Install bracing for multiple section assemblies to support assembly weight and to hold against system pressure. Install bracing as needed.

D. Fire Dampers:

1. At ceiling grille and diffuser fire dampers, provide thermal blankets where required by local authorities.
2. Install 1-1/2-hour rated, unless otherwise indicated, at locations shown and in accordance with SMACNA Fire, Smoke, and Radiation Damper Installation Guide for HVAC Systems.

3.08 ACCESS DOORS

A. [A: Ceilings:]

1. [B: In accordance with Section 08 30 00, Specialty Doors.]
2. [C: Install in nonaccessible ceilings below each electric duct heater, booster coil, motorized damper, terminal unit, smoke detector, and fire damper.]

B. Ductwork: Install access doors in ductwork, in accordance with manufacturer's instructions, at each:

1. Duct mounted fire damper.
2. Duct mounted smoke or ionization detector.
3. Electric duct heater.
4. Booster coil.
5. Humidifier.

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6. Motorized damper.
7. Sail switch.
8. Turning vane.
9. Volume damper.
10. Automatic damper.
11. Temperature controller.
12. Coil, on both upstream and downstream side.

3.09 EXTERNAL DUCT INSULATION

A. Refer to Section 23 07 00, HVAC Insulation.

3.10 MISCELLANEOUS ACCESSORIES

A. Prefabricated Roof Curb:

1. Refer to Section 07 70 01, Roof Specialties and Accessories.
2. Provide for ductwork roof penetrations and curb-mounted roof fans.
3. Roof curb installation, including flashing and counterflashing, shall provide watertight weatherproof enclosure.
4. Attach counterflashing to ductwork via rubber gasketed sheet metal screws.
5. Fill space between counterflashing and ductwork with silicon-based sealant. Sealant shall also be applied at all sheet metal screw locations.

B. Inspection Plates and Test Holes:

1. Where required in ductwork for balance measurements.
2. Test holes shall be airtight and noncorrosive with screw cap and gasket.
3. Extend cap through insulation.

3.11 DUCT SEALING

A. Seal duct seams and joints as follows:

1. In accordance with SMACNA requirements.
2. In accordance with the following:
   a. Pressure Classifications Greater than 3-Inch WC: Transverse joints, longitudinal seams, and duct penetrations.
   b. Pressure Classification Between 2-Inch and 3-Inch WC: Transverse joints and longitudinal seams.
   c. Pressure Classification Less than 2-Inch WC: Transverse joints only.

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3. In addition to other requirements, provide the following duct sealing:
    a. For interior ductwork, tape joints with Hardcast Lag-Rite tape and bonder or Ray-Chem shrink tape.
    b. For exterior ductwork, tape joints with Hardcast outdoor tape and rosin.

B. If no specific duct sealing requirements are specified, requirements of SMACNA manual shall govern.

C. Seal externally insulated ducts prior to insulation installation.

D. Provide additional duct sealing as required to comply with Article Ductwork Leakage Testing.

E. Seal all audible leaks.

3.12 FIRESTOPPING

A. Refer to Section 07 84 00, Firestopping.

3.13 PAINTING OF DUCTWORK

A. Refer to Section 09 90 00, Painting and Coating.

3.14 DUCTWORK LEAKAGE TESTING (CHEMICAL HOOD EXHAUST ONLY)

A. General:

1. Tests shall be conducted on completed ductwork systems.
2. Testing of partial installations or limited sections of ductwork will not be acceptable.
3. All ductwork leakage test procedures and results shall be submitted to Engineer for review.
4. Engineer shall retain the right to witness some or all ductwork leakage testing procedures.
5. Contractor shall notify Engineer in writing at least 5 working days prior to ductwork testing.

B. Leakage Criteria:

1. Assemble and install ductwork with maximum leakage limited as follows:
2. Constant Volume Systems:
    a. Exhaust Ductwork:
        1) Operating Pressure: 0- to 2-inch WC.
            a) Allowable Leakage: 2 percent of design airflow.

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C. Leakage Testing Method:

1. Contractor shall be responsible for providing all necessary test fans and calibrated measuring devices to accomplish ductwork leakage test and to demonstrate that ductwork systems leakage rate is less than maximum rate specified.
2. Pressure testing shall be accomplished using a pressure blower with a calibrated orifice and manometer.
3. Blower shall maintain system design static pressure during test.
4. Perform testing in accordance with procedures given in SMACNA HVAC Air Duct Leakage Test Manual.

3.15 BALANCING OF AIR SYSTEMS

A. Perform air balancing in accordance with requirements of Section 23 05 93, Testing, Adjusting, and Balancing for HVAC.

3.16 PROTECTION OF INSTALLED WORK

A. Open ends of installed ductwork systems shall be covered to prevent dust, foreign objects and water from entering ductwork.

B. Ductwork systems shall not be used for air conveyance until adequate air filtration devices are installed in air handling equipment, to prevent ingress of construction dust.

3.17 CLEANING

A. Ductwork shall be cleaned of rust, dust, and debris, both internally and externally, before placing in operation.

B. Before installing air outlets, use air handler to blow dry air through entire system at maximum attainable velocity. Provide temporary air filters for this operation.

C. If duct systems are found to contain construction debris at time of construction completion Contractor shall provide complete ductwork system cleaning in accordance with NADCA Standards.

END OF SECTION

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SECTION 23 34 00
HVAC FANS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Acoustical Society of America (ASA): S2.19, Mechanical Vibration—Balance Quality Requirements of Rigid Rotors—Part 1, Determination of Permissible Residual Unbalance.
2. Air Movement and Control Association International (AMCA):
   a. 99, Standards Handbook.
   b. 201, Fans and Systems.
   c. 203, Field Performance Measurement of Fan Systems.
   d. 204, Balance Quality and Vibration Levels for Fans.
   e. 210, Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating.
   f. 300, Reverberant Room Method for Sound Testing of Fans.
   g. 301, Methods for Calculating Fan Sound Ratings from Laboratory Test Data.
3. American Bearing Manufacturers Association (ABMA): 9, Load Ratings and Fatigue Life for Ball Bearings.
4. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE): 52.2, Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size.
5. ASTM International (ASTM):
   a. B117, Standard Practice for Operating Salt Spray (Fog) Apparatus.
   b. D2247, Standard Practice for Testing Water Resistance of Coatings in 100% Relative Humidity.
   c. D2794, Standard Test Method for Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact).
   d. D3363, Standard Test Method for Film Hardness by Pencil Test.
   e. D4167, Standard Specification for Fiber-Reinforced Plastic Fans and Blowers.
   f. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
6. National Electrical Manufacturers Association (NEMA).
7. National Fire Protection Association (NFPA): 45, Standard on Fire Protection for Laboratories Using Chemicals.
8. Occupational Safety and Health Act (OSHA).

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9. Society for Protective Coatings (SSPC):
    a. SP 3, Power Tool Cleaning.
    b. SP 5, White Metal Blast Cleaning.
    c. SP 6, Commercial Blast Cleaning.
    d. SP 10, Near-White Blast Cleaning.
10. Underwriters Laboratories Inc. (UL): 507, Safety Standard for Electric Fans.

1.02 DEFINITIONS

A. The following is a list of abbreviations which may be used in this section:

1. AC: Alternating Current.
2. CISD: Chemical Industry, Severe-Duty.
3. dB: Decibel.
4. DWDI: Double Width, Double Inlet.
5. FRP: Fiberglass Reinforced Plastic.
6. hp: Horsepower.
7. ODP: Open Drip Proof.
8. SWSI: Single Width, Single Inlet.
9. TEFC: Totally Enclosed, Fan Cooled.
10. UV: Ultra Violet
11. XP: Explosion Proof.

1.03 SUBMITTALS

A. Action Submittals:

1. Provide following for specified products:
    a. Identification as referenced in Contract Documents.
    b. Manufacturer’s name and model number.
    c. Descriptive specifications, literature, and drawings.
    d. Dimensions and weights.
    e. Fan sound power level data (reference 10 to power minus 12 watts) at design operating point.
    f. Fan Curves:
        1) Performance Curves Indicating:
            a) Relationship of flow rate to static pressure for various fan speeds.
            b) Brake horsepower curves.
            c) Acceptable selection range (surge curves, maximum revolutions per minute).
            d) Static pressure, capacity, horsepower demand and overall efficiency required at duty point, including drive losses.

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2) For variable air volume applications, indicate operating points at 100, 80, 60 and 40 percent of design capacity on fan curves including data to indicate effect of capacity control devices such as inlet vanes on flow, pressure, and brake horsepower.

g. Capacities and ratings.
h. Construction materials.
i. Fan type, size, class, drive arrangement, discharge, rotation, and bearings.
j. Wheel type, diameter, maximum revolutions per minute for fan class, operating revolutions per minute, and tip speed.
k. Motor data, including service factor and operating horsepower, as specified in Section 26 20 00, Low-Voltage AC Induction Motors.
l. Fan shaft first critical speed.
m. Belt service factor.
n. Drive assembly horsepower rating.
o. Sheave horsepower rating.
p. Power and control wiring diagrams, including terminals and numbers.
q. Factory run test and vibration test reports.
r. Vibration isolation.
s. Factory finish system.
t. Color selection charts where applicable.
u. Corrosion protection coating product data.

2. Seismic anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.
3. “Or Equal” Equipment:
   a. Where submitted equipment results in change to fan inlet or outlet ductwork configuration shown on Drawings, submit system effect factor calculations indicating increased static pressure requirements as described in AMCA 201.
   b. Where submitted equipment results in change to ductwork and equipment configuration shown on Drawings, submit detailed information on structural, mechanical, electrical, or other modifications necessary to adapt arrangement to equipment furnished.

B. Informational Submittals:

1. Seismic anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Recommended procedures for protection and handling of products prior to installation.
3. Manufacturer’s installation instructions.

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4. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements for the following:
   a. Motors specified to be premium efficient type.
   b. FRP fans.
5. Component and attachment testing seismic certificate of compliance as required by Section 01 45 33, Special Inspection**,** and Testing.
6. Test reports.
7. Operation and maintenance data in conformance with Section 01 78 23, Operation and Maintenance Data. Include as-built version of equipment schedules.

1.04 QUALITY ASSURANCE

A. Performance Ratings: Tested in accordance with AMCA 210.

B. Sound Ratings: Tested in accordance with AMCA 300.

C. Fabrication: In accordance with AMCA 99.

1.05 EXTRA MATERIALS

A. Furnish, tag, and box for shipment and storage the following **[A: spare parts,] [B: special tools,] [C: and] [D: materials:]**

Item	Quantity
Vee Belts	One complete set per unit
Special tools required to maintain or dismantle	One complete set for each different size unit

B. Delivery: In accordance with Section 01 61 00, Common Product Requirements.

PART 2 PRODUCTS

2.01 EQUIPMENT SCHEDULES

A. Some specific equipment requirements are listed in Equipment Schedule. Refer to Drawings.

2.02 GENERAL

A. Spark Resistant Construction: Fans required to be spark resistant shall comply with requirements of AMCA 99-0401.

B. Operating Limits: Fans designated to meet a specified fan class shall comply with requirements of AMCA 99-2408.

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C. Acoustical Levels: Equipment selections shall produce sound power levels in each octave band no greater than shown in Equipment Schedule.

D. Fan Drives:

1. Drive assembly shall be sized for a minimum 140 percent of fan motor horsepower rating.
2. Furnish multiple drive belts where motor horsepower is 2 hp or larger.
3. Sheaves:
    a. Capable of providing 150 percent of motor horsepower.
    b. Unless otherwise noted, furnish belt-driven fans with cast iron or flanged steel sheaves.
4. Drive Adjustment:
    a. When fixed-pitch sheaves are furnished, accomplish system air balancing by either trial of different fixed-pitch sheaves or use of temporary adjustable-pitch sheaves.
    b. Provide trial and final sheaves, as well as drive belts, as required.
5. Fan Shafts: First critical speed of at least 125 percent of fan maximum operating speed.
6. Provide speed test openings at shaft locations.
7. Belts: Oil and heat resistant, nonstatic type.
8. Motors:
    a. Motors 20 hp or Smaller:
        1) Variable pitch V-belt sheaves allowing at least 20 percent speed variation.
        2) Final operating point shall be at approximate sheave midpoint.
    b. Motors Larger than 20 hp: Fixed-pitch sheaves.
    c. Furnish motors for V-belt drives with adjustable rails or bases.
9. Weather Cover: For outdoor applications, factory fabricated drive assembly of same material as fan housing, unless specified otherwise.
10. Belt and Shaft Guards:
    a. Easily removable and to enclose entire drive assembly, meeting federal, OSHA requirements.
    b. Guard faces of expanded metal having minimum 60 percent free area for ventilation.
    c. Bright yellow finish.

E. Finishes:

1. Carbon Steel Parts: Factory finish as follows, unless indicated otherwise.
    a. Parts cleaned and chemically pretreated with phosphatizing process.
    b. Alkyd enamel primer.
    c. Air dry enamel topcoat.

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2. Aluminum Parts: Finished smooth and left unpainted, unless stated otherwise.
3. Stainless Steel Parts: Finished smooth and left unpainted.
4. Fiberglass Parts: Finished in accordance with Paragraph Fiberglass Material.

2.03 CABINET FAN

A. General:

1. Factory-assembled, ceiling, wall or inline mounted, centrifugal cabinet fan; including housing, fan wheel, drive assembly, motor and accessories.
2. Bearing AMCA Certified Ratings Seal for sound and air performance.

B. Housing:

1. Material: Minimum 20-gauge galvanized steel.
2. Construction:
   a. Minimum 14-gauge blower and motor support frame.
   b. Lined with minimum 1/2-inch acoustical insulation.
   c. Outlet duct collar with integral reinforced aluminum backdraft damper, with nylon bushings.
   d. Motor mounted on resilient vibration isolators.
   e. Motor and blower removable from unit without cabinet disassembly.
   f. Removable cabinet access panels.
   g. Air Inlet: Field convertible for bottom or end air inlet configuration.
   h. Predrilled universal mounting brackets, adjustable.

C. Wheel: Centrifugal forward curved type, galvanized steel or plastic construction.

D. Shaft, Bearings, Drive:

1. Shafts: Turned, ground and polished carbon steel.
2. Bearings: Grease lubricated, precision antifriction ball, sealed type.
3. Drives:
   a. In accordance with Paragraph Fan Drives.
   b. Factory set to specified fan revolutions per minute.
   c. Type: Direct.

E. Electrical:

1. Integral wiring box.
2. Factory-installed disconnect receptacle.

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F. Accessories: Provide as scheduled in Equipment Schedule, and as follows:

1. Ceiling Grille: Factory fabricated, aluminum construction, white baked enamel finish.
2. Speed Controller: Solid state electronics.
3. Wall Cap:
    a. Aluminum construction, mill finish.
    b. Built-in backdraft damper.
    c. Bird screen.
    d. Round duct connection.

G. Manufacturers and Products:

1. Loren Cook; Gemini Series.
2. Greenheck; SP Series.
3. ACME; Model VQ Series.
4. Twin City Fan; T Series.

2.04 INLINE FAN, CENTRIFUGAL, SQUARE

A. General:

1. Factory-assembled, centrifugal, inline fan, square housing configuration; including housing, fan wheel, drive assembly, motor and accessories.
2. Bearing AMCA Certified Ratings Seal for sound and air performance.

B. Housing:

1. Construction: All aluminum.
2. Integral duct collars.
3. Removable side panels, for ease of service.
4. Field convertible for side air discharge configuration.
5. Predrilled universal mounting brackets for vertical or horizontal installation.
6. Inlets: Aerodynamic aluminum venturi.
7. Corrosion-resistant fasteners.
8. Drive belt and bearings separated from air steam by enclosure.

C. Wheel:

1. Centrifugal backward inclined, 100 percent aluminum construction.
2. Precision machined cast aluminum hub.
3. Die-formed airfoil or backward inclined blades.
4. Matched to inlet venturi.
5. Attached to fan shaft with split taper lock bushing.

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D. Shaft, Bearings, Drive:

1. Shafts:
    a. Turned, ground and polished carbon steel.
    b. Keyed for sheave installation.
2. Bearings:
    a. Grease lubricated, precision antifriction ball, self-aligning, pillow block style, relubricatable or sealed type.
    b. Selected for average life (ABMA 9 L_{50}) of not less than 200,000 hours operation at maximum cataloged operating speed.
3. Drives:
    a. In accordance with Paragraph Fan Drives.
    b. Factory set to specified fan revolutions per minute.
    c. Type: Belt or Direct, as indicated in Equipment Schedule.
    d. Arrangement: As scheduled in Equipment Schedule.

E. Accessories: Provide as scheduled in Equipment Schedule, and as follows:

1. Belt Guard: Sheet metal construction, OSHA type.
2. Motor and Drive Cover:
    a. Factory fabricated, OSHA type.
    b. Sheet metal construction, same material as fan housing.
    c. Vented, openings sufficient size for proper motor cooling.
    d. Fan speed controller.
3. Gravity Backdraft Damper: Galvanized steel frame, aluminum blades, brass pivot pins, neoprene seals on damper blade edges, gravity operation, and adjustable counterweight.
4. Insulated Housing: Fiberglass insulation, 1-inch thick, neoprene coated, on interior of housing.
5. Inlet Screen: Removable 1-inch mesh screen, aluminum construction, overexposed inlets.
6. Disconnect: Factory installed, nonfused, NEMA Type: as scheduled.
7. Single Side Discharge: Package consisting of side duct connection collar and rear-discharge blank-off panel.
8. Dual Side Discharge: Package consisting of side duct connection collars and rear-discharge blank-off panel.
9. Bearing Lubrication Lines:
    a. Extended to outside of fan housing.
    b. Terminate with zerk fittings.
10. Corrosion Protection Coating:
    a. Provide factory-applied corrosion protection coating on the following:
        1) Wheel.
        2) Housing.
        3) Accessories.
        4) Interior surfaces in contact with airstream.

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b. **[T: Coating system shall be [U: baked enamel] [V: baked polyester] [W: air-dry epoxy] [X: baked epoxy] [Y: air-dry phenolic] [Z: baked phenolic] [A: baked epoxy phenolic] [B: as scheduled in fan Equipment Schedule], and shall be in accordance with Article Corrosion Protection Coating.]**

c. **[C: Coating system shall be in accordance with Section 09 90 00, Painting and Coating.]**

F. Manufacturers and Products:

1. Greenheck; Model BSQ (Belt); SQ (Direct).
2. Loren Cook; Model SQNB (Belt); SQND (Direct).
3. ACME; Centri-Master Model XB Series (Belt); XD (Direct).
4. Twin City Fan (Aerovent); Model BSI (Belt); Model ISD (Direct).

2.05 INLINE FAN, TUBULAR CENTRIFUGAL

A. General:

1. Factory-assembled tubular centrifugal fan, belt drive; including housing, fan wheel, drive assembly, motor, and accessories.
2. Fan Performance: AMCA 99-2408 Class **[A: I] [B: II] [C: III] [D: as scheduled]**.
3. Bearing AMCA Certified Ratings Seal for sound and air performance.

B. Housings:

1. Material: **[A: Steel.] [B: Aluminum.] [C: Type 304 stainless steel.] [D: Type 316 stainless steel.]**
2. Construction:
   a. Heavy-gauge rolled metal casing, with continuous seam welding.
   b. Air straightening vanes at fan outlet, integral with shaft, bearing support, and outer casing, fully welded.
   c. Bearing and drive components isolated from air stream within continuously welded tunnel.
   d. Lifting lugs welded to housing.
   e. Mounting brackets, welded to housing, as required for indicated fan arrangement.
3. Bearing Lubrication Lines:
   a. Extended to outside of fan housing.
   b. Type 316 stainless steel construction.
   c. Terminate with zerk fittings.
4. Inlets: Die-formed bell mouth, matched to fan wheel inlet shroud.
5. Motor Base Plate: Minimum of 3/16-inch metal plate, welded to fan housing, to provide belt tensioning and adjustment.
6. Duct Flanges: Angle ring flanges, same diameter as housing, at fan inlet and outlet, heavy construction, factory drilled.

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C. Wheel:

1. Material: **[A: Steel] [B: Aluminum]** construction.
2. Centrifugal, one-piece, nonoverloading, backwardly inclined blades.
3. Blades continuously welded to inlet shroud and backplate.
4. Attached to fan shaft with split taper lock bushing.

D. Shaft, Bearings, Drive:

1. Shafts:
   a. Turned, ground and polished hot-rolled carbon steel.
   b. Keyed for sheave installation.
   c. Corrosion protection coating.
2. Bearings:
   a. Grease lubricated, precision antifriction ball, self-aligning type.
   b. Mounted in cast iron pillow block housing.
   c. Selected for average life (ABMA 9 L_{50}) of not less than 200,000 hours operation at maximum cataloged operating speed.
   d. Suitable for fan operation in vertical configuration.
3. Drives:
   a. In accordance with Paragraph Fan Drives.
   b. Factory set to the specified fan revolutions per minute.
   c. Type: Belt.
   d. Arrangement: **[A: As scheduled in Equipment Schedule.] [B: Arrangement 1.] [C: Arrangement 4.] [D: Arrangement 9.] [E: Vertical.]**

E. Roof Mount Accessories:

1. Motor and Drive Cover:
   a. Factory fabricated; OSHA type.
   b. Sheet metal construction, same material as fan housing.
   c. Vented, openings sufficient size for proper motor cooling.
2. Stack Cap:
   a. Factory fabricated.
   b. Same material as fan housing.
   c. Integral backdraft dampers.
3. Curb Base:
   a. Factory fabricated.
   b. Sized to adapt fan inlet to roof curb.
   c. Same material as fan housing.

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F. Accessories: Provide **[A: as scheduled in Equipment Schedule.] [B: as follows:]**

1. Roof Curb:
   a. Factory fabricated.
   b. **[C: With] [D: Without]** damper tray.
   c. Sloped to match roof pitch and to provide level top.
   d. Height Above Finished Roof: **[E: 12 inches.] [F: As scheduled.]**
   e. **[G: Galvanized steel] [H: Aluminum]** construction.
   f. Mitered continuous welded corner seams.
   g. Pressure-treated wood nailer.
   h. Insulation: Minimum 1-1/2 inches thick, 3 pounds per cubic foot density, rigid mineral fiberboard insulation with metal liner.
2. Housing Access Doors: Bolted and gasketed.
3. Disconnect: Factory installed, nonfused, NEMA Type **[I: 3R] [J: 4X]**.
4. Motor and Drive Cover:
   a. Factory fabricated; OSHA type.
   b. Sheet metal construction, same material as fan housing.
   c. Vented, openings sufficient size for proper motor cooling.
5. Belt Guard: Sheet metal construction, OSHA type.
6. Inlet Vanes: Variable position, for manual or automatic operation.
7. Housing Access Doors: Bolted and gasketed.
8. Shaft Seal: **[K: Elastomeric.] [L: Ceramic felt.] [M: Lubricated.] [N: Stuffing box.] [O: Type as scheduled.]**
9. Inlet Screen: Metal, spiral wire type, OSHA approved, removable.
10. Outlet Screen: Metal, spiral wire type, OSHA approved, removable.
11. Support Base: Welded metal, for standard platform or floor mounting.
12. Spark Resistant Construction: AMCA 99-0401 Type **[P: A] [Q: B] [R: C] [S: as scheduled]**.
13. Corrosion Protection Coating:
    a. Provide factory-applied corrosion protection coating on these fan components:
       1) Wheel.
       2) Housing.
       3) Accessories.
       4) Interior surfaces in contact with airstream.
    b. **[T: Coating system shall be [U: baked enamel] [V: baked polyester] [W: air-dry epoxy] [X: baked epoxy] [Y: air-dry phenolic] [Z: baked phenolic] [A: baked epoxy phenolic] [B: as scheduled in Equipment Schedule], and shall be in accordance with Article Corrosion Protection Coating.]**
    c. **[C: Coating system shall be in accordance with Section 09 90 00, Painting and Coating.]**

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G. Manufacturers and Products:

1. Aerovent; Model CBD.
2. Cook; Model TCNH-B.
3. Greenheck; Model TCB.

2.06 INLINE FAN, TUBULAR CENTRIFUGAL, FIBERGLASS

A. General:

1. Factory-assembled tubular centrifugal fan, fiberglass construction, belt drive; including housing, fan wheel, drive assembly, motor and accessories.
2. Fiberglass Construction: In accordance with ASTM D4167.
3. Fan Performance: AMCA 99-2408 Class **[A: I] [B: II] [C: III] [D: as scheduled]**.
4. Air Stream Hardware: Type 316 stainless steel.

B. Fiberglass Material:

1. Construction: Resin reinforced fiber cloth and mat.
2. Resin:
   a. **[A: Polyester] [B: Vinyl ester]** thermosetting resin.
   b. Selected by fabricator, subject to approval by Engineer.
   c. Suitable for intended service with no fillers or thixotropic agents.
   d. Premium grade and corrosion resistant.
   e. Structural wall resin may be of different chemical resistance, subject to conditions of service and approval by Engineer.
   f. **[C: Flame Spread Index:**
      1) **ASTM E84, less than 25; fire retardant additives used only in structural layer.**
      2) **Structural wall resin shall contain a minimum of 3 percent antimony trioxide to achieve required flame spread index.]**
   g. For outdoor locations, add ultraviolet absorbers to surfacing resin to improve weather resistance.
   h. For interior locations, final coat shall be factory applied intumescent coating to achieve designated results for low smoke development.
   i. Color:
      1) Use no dyes, pigments, or colorants **[D: , except in exterior gel coat]**.
      2) Exterior gel coat shall be **[E: white] [F:]**.

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3. Reinforcement:
    a. Veil: Chemical surfacing mat, **[G: Type C (chemical) glass veil] [H: Nexus Surface Veil] [I: carbon veil]**.
    b. Chopped Strand Mat: Type E glass, minimum 1-1/2 ounces per square foot, with silane finish and styrene soluble binder.
    c. Continuous Roving for Chopper Gun Spray-Up: Type E glass.
    d. Woven Roving: Type E glass, nominal 24 ounces per square yard, 4 by 5 weave, with silane type finish.
4. Laminate:
    a. Inner Surface (Veil):
        1) Resin rich, veil reinforced, 10 mils to 20 mils thick.
        2) Use no additives.
        3) Finish and binder compatible with lay-up resin.
        4) Reinforcement Content: Not more than 20 percent.
    b. Interior (Corrosion) Layer:
        1) Resin rich, at least two plies of chopped strand mat, nominal 100 mils to 120 mils thick.
        2) Use no additives.
        3) Construct interior layer of resin reinforced with at least two plies of chopped strand mat backing the veil.
        4) Reinforcement Content: 25 plus or minus 5 percent.
    c. Exterior (Structural) Layer:
        1) Resin with mat, cloth, woven roving or chopped strand glass reinforcement.
        2) Enough resin present to prevent surface fiber show.
        3) Exterior surface relatively smooth, with no exposed fibers or sharp projections.
    d. Wall Thickness: As required for equipment structural integrity, but not less than 3/16 inch.

C. Housing:

1. Material: Fiberglass construction.
2. Construction:
    a. Tubular housing shell.
    b. Integral predrilled duct connection flanges to ensure housing concentricity and housing strength.
    c. Air straightening vanes, fiberglass construction, at fan outlet, interconnected with inner and outer shell.
    d. Bearing Base and Drive Enclosure:
        1) Bearings and belts enclosed in air insulated fiberglass housing for protection from air stream gases, fumes, and vapors.
        2) Supported by tapered gussets interlocked into outer housing.
        3) Constructed of laminated glass and resin.

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4) Bearing housing furnished with a bolted, removable Teflon shaft closure plate to facilitate bearing access.
5) Viton shaft seal.

e. Lifting lugs, steel, bolted to fan housing flanges.
f. Mounting brackets, steel, bolted to fan housing flanges, as required for indicated fan arrangement.

3. Inlet:
   a. Bolted, removable.
   b. Streamlined, bell mouth type.
   c. Fiberglass construction.
   d. Matched to fan wheel inlet shroud.
4. Bearing Lubrication Lines:
   a. Extended to outside of fan housing.
   b. Type 316 stainless steel construction.
   c. Terminated with zerk fittings.
5. Motor Base Plate:
   a. Minimum 3/16-inch steel plate.
   b. Bolted between gussets integral to fan housing flanges.
   c. Provision for belt tensioning and adjustment.

D. Wheel:

1. Material: Fiberglass construction.
2. Centrifugal, one-piece, nonoverloading, backwardly inclined airfoil blades.
3. Mechanically fastened to end of fan shaft by Type 316 stainless steel bolt.

E. Shaft, Bearings, Drive:

1. Shafts:
   a. Turned, ground and polished Type 316 stainless steel.
   b. Keyed for sheave installation.
2. Bearings:
   a. Grease lubricated, precision antifriction, ball self-aligning type.
   b. Mounted in cast iron pillow block housing.
   c. Selected for average life (ABMA 9 L_{50}) of not less than 200,000 hours operation at maximum cataloged operating speed.
   d. Suitable for fan operation in vertical configuration.
3. Drives:
   a. In accordance with Paragraph Fan Drives.
   b. Factory set to specified fan revolutions per minute.
   c. Type: Belt.
   d. Arrangement: **[A: As scheduled in Equipment Schedule.] [B: Arrangement 1.] [C: Arrangement 4.] [D: Arrangement 9.] [E: Vertical.]**

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F. Accessories: Provide **[A: as scheduled in Equipment Schedule.] [B: as follows:]**

1. Housing Access Doors: Fiberglass construction, bolted, and gasketed.
2. Disconnect: Factory installed, nonfused, NEMA Type **[C: 3R] [D: 4X]**.
3. Motor and Drive Cover:
   a. Factory fabricated; OSHA type.
   b. Fiberglass construction, same material as fan housing.
   c. Vented, openings sufficient size for proper motor cooling.
4. Belt Guard: Sheet metal construction, OSHA type.
5. Inlet Vanes: Variable position, for manual or automatic operation.
6. Housing Access Doors: Bolted and gasketed.
7. Shaft Seal: **[E: Elastomeric.] [F: Ceramic felt.] [G: Lubricated.] [H: Stuffing box.] [I: Type as scheduled.]**
8. Inlet Screen: Metal, spiral wire type, OSHA approved, removable.
9. Outlet Screen: Metal, spiral wire type, OSHA approved, removable.
10. Nameplates: Type 316 stainless steel manufacturer's nameplates.
11. Support Base: Welded metal, for standard platform or floor mounting.
12. Spark Resistant Construction: AMCA 99-0401 Type **[J: A] [K: B] [L: C] [M: as scheduled]**.
13. Corrosive Service Metal Components:
    a. Metal components including fan shaft, motor pedestal, motor slide base, lube lines, accessories, hardware shall be Type 316 stainless steel.
    b. Coated steel components will not be accepted.
14. Corrosion Protection Coating:
    a. Provide factory-applied corrosion protection coating on steel fan components.
    b. **[N: Coating system shall be [O: baked enamel] [P: baked polyester] [Q: air-dry epoxy] [R: baked epoxy] [S: air-dry phenolic] [T: baked phenolic] [U: baked epoxy phenolic] [V: as scheduled in fan Equipment Schedule], and shall be in accordance with Article Corrosion Protection Coating.]**
    c. **[W: Coating system shall be in accordance with Section 09 90 00, Painting and Coating.]**

G. Manufacturers and Products:

1. Aerovent; Model CBDF.
2. Hartzell; Model 40.

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2.07 INLINE FAN, TUBE AXIAL

A. General:

1. Factory-assembled tube-axial fan; including housing, fixed pitch fan wheel, drive assembly, motor and accessories.
2. Bearing AMCA Certified Ratings Seal for sound and air performance.

B. Housings:

1. Material: **[A: Steel.] [B: Aluminum.] [C: Type 304 stainless steel.] [D: Type 316 stainless steel.]**
2. Construction:
   a. Heavy-gauge rolled metal casing, with continuous seam welding.
   b. Bearing and drive components isolated from air stream within continuously welded tunnel.
   c. Lifting lugs welded to housing.
   d. Mounting brackets, welded to housing, as required for indicated fan arrangement.
3. Bearing Lubrication Lines:
   a. Extended to outside of fan housing.
   b. Type 316 stainless steel construction.
   c. Terminate with zerk fittings.
4. Motor Base Plate: Minimum of 3/16-inch metal plate, welded to fan housing, to provide belt tensioning and adjustment.
5. Duct Flanges: Angle ring flanges, same diameter as housing, at fan inlet and outlet, heavy construction, factory drilled.

C. Wheel:

1. Hub: Cast aluminum.
2. Blades: Cast aluminum airfoil design.
3. Wheel assembly attached to fan shaft with split taper lock bushing.

D. Shaft, Bearings, Drive:

1. Shafts:
   a. Turned, ground, and polished hot-rolled carbon steel.
   b. Keyed for sheave installation.
   c. Corrosion protection coating.
2. Bearings:
   a. Grease lubricated, precision antifriction ball, self-aligning type.
   b. Mounted in cast iron pillow block housing.
   c. Selected for average life (ABMA 9 L_{50}) of not less than 200,000 hours operation at maximum cataloged operating speed.
   d. Suitable for fan operation in vertical configuration.

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3. Drives:
    a. In accordance with Paragraph Fan Drives.
    b. Factory set to specified fan revolutions per minute.
    c. Type: **[A: Belt or direct, as indicated in Equipment Schedule.] [B: Belt.] [C: Direct.]**
    d. Arrangement: **[D: As scheduled in Equipment Schedule.] [E: Arrangement 1.] [F: Arrangement 4.] [G: Arrangement 9.] [H: Vertical.]**

E. Roof Mount Accessories:

1. Motor and Drive Cover:
    a. Factory fabricated; OSHA type.
    b. Sheet metal construction, same material as fan housing.
    c. Vented, openings sufficient size for proper motor cooling.
2. Stack Cap:
    a. Factory fabricated.
    b. Same material as fan housing.
    c. Integral backdraft dampers.
3. Curb Base:
    a. Factory fabricated.
    b. Sized to adapt fan inlet to roof curb.
    c. Same material as fan housing.

F. Accessories: Provide **[A: as scheduled in Equipment Schedule.] [B: as follows:]**

1. Roof Curb:
    a. Factory fabricated.
    b. **[C: With] [D: Without]** damper tray.
    c. Sloped to match roof pitch and to provide level top.
    d. Height Above Finished Roof: **[E: 12 inches.] [F: As scheduled.]**
    e. **[G: Galvanized steel] [H: Aluminum]** construction.
    f. Mitered continuous welded corner seams.
    g. Pressure-treated wood nailer.
    h. Insulation: Minimum 1-1/2 inches thick, 3 pounds per cubic foot density, rigid mineral fiberboard insulation with metal liner.
2. Housing Access Doors: Bolted and gasketed.
3. Disconnect: Factory installed, nonfused, NEMA Type **[I: 3R] [J: 4X]**.
4. Motor and Drive Cover:
    a. Factory fabricated; OSHA type.
    b. Sheet metal construction, same material as fan housing.
    c. Vented, openings sufficient size for proper motor cooling.
5. Belt Guard: Sheet metal construction, OSHA type.
6. Inlet Vanes: Variable position, for manual or automatic operation.
7. Shaft Seal: Elastomeric.

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8. Inlet Screen: Metal, spiral wire type, OSHA approved, removable.
9. Outlet Screen: Metal, spiral wire type, OSHA approved, removable.
10. Inlet Bell: Factory fabricated aerodynamic bell, bolted to fan inlet, same material as fan housing.
11. Inlet Cone: Factory fabricated, conical fan to duct transition, bolted to housing flange, same material as fan housing.
12. Outlet Cone: Factory fabricated, conical fan to duct transition, bolted to housing flange, same material as fan housing.
13. Support Base: Welded metal, for standard platform or floor mounting.
14. Spark Resistant Construction: AMCA 99-0401 Type **[K: A] [L: B] [M: C] [N: as scheduled]**.
15. Corrosion Protection Coating:
    a. Provide factory-applied corrosion protection coating on these fan components:
        1) Wheel (or propeller).
        2) Housing.
        3) Accessories.
        4) Interior surfaces in contact with airstream.
    b. **[O: Coating system shall be [P: baked enamel] [Q: baked polyester] [R: air-dry epoxy] [S: baked epoxy] [T: air-dry phenolic] [U: baked phenolic] [V: baked epoxy phenolic] [W: as scheduled in fan Equipment Schedule], and shall be in accordance with Article Corrosion Protection Coating.]**
    c. **[X: Coating system shall be in accordance with Section 09 90 00, Painting and Coating.]**

G. Manufacturers and Products:

1. Aerovent; Model TA (Direct); TABD (Belt).
2. Cook; Model EDD (Direct); EDB (Belt).
3. Greenheck; Model TDI (Direct); TBI (Belt).

2.08 INLINE FAN, VANE AXIAL

A. General:

1. Factory-assembled vane-axial fan; including housing with integral vanes, adjustable pitch fan wheel, drive assembly, motor and accessories.
2. Bearing AMCA Certified Ratings Seal for sound and air performance.

B. Housings:

1. Material: **[A: Steel.] [B: Aluminum.] [C: Type 304 stainless steel.] [D: Type 316 stainless steel.]**

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2. Construction:
    a. Heavy gauge rolled metal casing, with continuous seam welding.
    b. Air straightening vanes at propeller discharge, integral with housing, fully welded.
    c. Bearing and drive components isolated from air stream within continuously welded tunnel.
    d. Lifting lugs welded to housing.
    e. Mounting brackets, welded to housing, as required for indicated fan arrangement.
3. Bearing Lubrication Lines:
    a. Extended to outside of fan housing.
    b. Type 316 stainless steel construction.
    c. Terminate with zerk fittings.
4. Motor Base Plate: Minimum of 3/16-inch metal plate, welded to fan housing, to provide belt tensioning and adjustment.
5. Duct Flanges: Angle ring flanges, same diameter as housing, at fan inlet and outlet, heavy construction, factory drilled.

C. Wheel:

1. Hub:
    a. Cast aluminum.
    b. Streamlined hub cover.
2. Blades:
    a. Cast aluminum
    b. Adjustable pitch.
    c. Factory set to required pitch.
    d. Blade angle field adjustable.
3. Wheel assembly attached to fan shaft with split taper lock bushing.

D. Shaft, Bearings, Drive:

1. Shafts:
    a. Turned, ground, and polished hot-rolled carbon steel.
    b. Keyed for sheave installation.
    c. Corrosion protection coating.
2. Bearings:
    a. Grease lubricated, precision antifriction ball, self-aligning type.
    b. Mounted in cast iron pillow block housing.
    c. Selected for average life (ABMA 9 L_{50}) of not less than 200,000 hours operation at maximum cataloged operating speed.
    d. Suitable for fan operation in vertical configuration.
3. Drives:
    a. In accordance with Paragraph Fan Drives.
    b. Factory set to specified fan revolutions per minute.

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c. Type: **[A: Belt or direct, as indicated in Equipment Schedule.] [B: Belt.] [C: Direct.]**
d. Arrangement: **[D: As scheduled in Equipment Schedule.] [E: Arrangement 1.] [F: Arrangement 4.] [G: Arrangement 9.] [H: Vertical.]**

E. Roof Mount Accessories:

1. Motor and Drive Cover:
   a. Factory fabricated; OSHA type.
   b. Sheet metal construction, same material as fan housing.
   c. Vented, openings sufficient size for proper motor cooling.
2. Stack Cap:
   a. Factory fabricated.
   b. Same material as fan housing.
   c. Integral backdraft dampers.
3. Curb Base:
   a. Factory fabricated.
   b. Sized to adapt fan inlet to roof curb.
   c. Same material as fan housing.

F. Accessories: Provide **[A: as scheduled in Equipment Schedule.] [B: as follows:]**

1. Roof Curb:
   a. Factory fabricated.
   b. **[C: With] [D: Without]** damper tray.
   c. Sloped to match roof pitch and to provide level top.
   d. Height Above Finished Roof: **[E: 12 inches.] [F: As scheduled.]**
   e. **[G: Galvanized steel] [H: Aluminum]** construction.
   f. Mitered continuous welded corner seams.
   g. Pressure-treated wood nailer.
   h. Insulation: Minimum 1-1/2 inches thick, 3 pounds per cubic foot density, rigid mineral fiberboard insulation with metal liner.
2. Housing Access Doors: Bolted and gasketed.
3. Disconnect: Factory-installed, nonfused, NEMA Type **[I: 3R] [J: 4X]**.
4. Motor and Drive Cover:
   a. Factory fabricated; OSHA type.
   b. Sheet metal construction, same material as fan housing.
   c. Vented, openings sufficient size for proper motor cooling.
5. Belt Guard: Sheet metal construction; OSHA type.
6. Inlet Vanes: Variable position, for manual or automatic operation.
7. Shaft Seal: Elastomeric.
8. Inlet Screen: Metal, spiral wire type, OSHA approved, removable.
9. Outlet Screen: Metal, spiral wire type, OSHA approved, removable.

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10. Inlet Bell: Factory fabricated aerodynamic bell, bolted to fan inlet, same material as fan housing.
11. Inlet Cone: Factory fabricated, conical fan to duct transition, bolted to housing flange, same material as fan housing.
12. Outlet Cone: Factory fabricated, conical fan to duct transition, bolted to housing flange, same material as fan housing.
13. Support Base: Welded metal, for standard platform or floor mounting.
14. Spark Resistant Construction: AMCA 99-0401 Type **[K: A] [L: B] [M: C] [N: as scheduled]**.
15. Corrosion Protection Coating:
    a. Provide factory-applied corrosion protection coating on these fan components:
        1) Wheel (or propeller).
        2) Housing.
        3) Accessories.
        4) Interior surfaces in contact with airstream.
    b. **[O: Coating system shall be [P: baked enamel] [Q: baked polyester] [R: air-dry epoxy] [S: baked epoxy] [T: air-dry phenolic] [U: baked phenolic] [V: baked epoxy phenolic] [W: as scheduled in fan Equipment Schedule], and shall be in accordance with Article Corrosion Protection Coating.]**
    c. **[X: Coating system shall be in accordance with Section 09 90 00, Painting and Coating.]**

G. Manufacturers and Products:

1. Aerovent; Model VWBD (Belt); VW (Direct).
2. Cook; Model AVAB (Belt); AVAD (Direct).
3. Greenheck; Model VAB (Belt); VAD (Direct).

2.09 ROOF FAN, CENTRIFUGAL UPBLAST

A. General:

1. Factory-assembled centrifugal upblast roof fan; including housing, fan wheel, drive assembly, motor and accessories.
2. Bearing AMCA Certified Ratings Seal for sound and air performance.

B. Housing:

1. Construction: Spun-formed aluminum, minimum 16-gauge marine alloy.
2. Windband: Finish with rolled bead.
3. Top Cap: Motor access via quick release latches.
4. Motor completely sealed from exhaust air stream.
5. Motor cooling via air breather tubes.
6. Integral conduit chase for wiring.

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7. Drain trough at lowest point of housing.
8. Fan Inlet:
    a. Full inlet cone of aluminum construction.
    b. Match inlet shroud.

C. Wheel:

1. Aluminum construction, backward inclined centrifugal, nonoverloading type.
2. Machined, cast aluminum hub.
3. Matched to deep spun inlet venturi.

D. Shaft, Bearings, Drive:

1. Shaft:
    a. Turned, ground, and polished carbon steel.
    b. Keyed for sheave installation.
    c. Zinc-phosphate coated and oil emulsion-dipped.
2. Bearings:
    a. Grease lubricated, precision antifriction ball, self-aligning, pillow block style.
    b. Selected for average life (ABMA 9 L_{50}) of not less than 200,000 hours operation at maximum cataloged operating speed.
    c. Terminate with zerk fittings.
3. Drives:
    a. In accordance with Paragraph Fan Drives.
    b. Factory set to specified fan revolutions per minute.
    c. Type: **[A: Belt or direct, as indicated in Equipment Schedule.] [B: Belt.] [C: Direct.]**

E. Accessories: Provide **[A: as scheduled on Equipment Schedule.] [B: as follows:]**

1. Gravity Backdraft Damper: Gravity operation, adjustable counterweight, and aluminum construction.
2. Motorized Damper: Aluminum frame, aluminum blades, aluminum hinge pins with nylon bushings, **[C: 120V] [D: 24V]** operator.
3. Bird Screens: Aluminum construction.
4. Roof Curb:
    a. Factory fabricated, **[E: galvanized steel] [F: aluminum]** construction.
    b. **[G: With] [H: Without]** damper tray.
    c. Sloped to match roof pitch, and to provide level top.
    d. Height Above Finished Roof: **[I: 12 inches.] [J: As scheduled.]**
    e. Mitered continuous welded corner seams.

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f. Pressure-treated wood nailer.
g. Insulation: Minimum 1-1/2 inches thick, 3 pounds per cubic foot density, rigid mineral fiberboard insulation with metal liner.

5. Disconnect: Factory installed, nonfused, NEMA Type **[K: 3R] [L: 4X] [M: as scheduled]**.
6. Bearing Lubrication Lines:
   a. Extended to outside of fan housing.
   b. Type 316 stainless steel construction.
   c. Terminate with zerk fittings.
7. Spark Resistant Construction Classification: AMCA 99-0401 Type **[N: A] [O: B] [P: C] [Q: as scheduled]**.
8. Corrosion Protection Coating:
   a. Provide factory-applied corrosion protection coating on these fan components:
      1) Wheel.
      2) Housing.
      3) Accessories.
      4) Interior surfaces in contact with airstream.
   b. **[R: Coating system shall be [S: baked enamel] [T: baked polyester] [U: air-dry epoxy] [V: baked epoxy] [W: air-dry phenolic] [X: baked phenolic] [Y: baked epoxy phenolic] [Z: as scheduled in fan Equipment Schedule], and shall be in accordance with Article Corrosion Protection Coating.]**
   c. **[A: Coating system shall be in accordance with Section 09 90 00, Painting and Coating.]**

F. Manufacturers and Products:

1. Aerovent: Model ATB.
2. Cook; Model ACRUD (Direct Drive); ACRUB (Belt Drive).
3. Greenheck; Model CUE (Direct Drive); CUBE (Belt Drive).
4. ACME, Model PDU (Direct Drive); PNU (Belt Drive).
5. Twin City Fan; BCRU.

2.10 ROOF FAN, FIBERGLASS CENTRIFUGAL UPBLAST

A. General:

1. Factory-assembled centrifugal upblast fiberglass roof fan; including housing, fan wheel, drive assembly, motor, and accessories.
2. Fiberglass Construction: In accordance ASTM D4167.
3. Suitable to convey air at temperatures up to 150 degrees F.
4. Bearing AMCA Certified Ratings Seal for sound and air performance.

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B. Fiberglass Material:

1. Construction: Resin reinforced fiber cloth and mat.
2. Resin:
   a. **[A: Polyester] [B: Vinyl ester]** thermosetting resin.
   b. No fillers or thixotropic agents.
   c. Premium grade and corrosion resistant.
   d. Structural wall resin may be of different chemical resistance, subject to conditions of service and approval by Engineer.
   e. **[C: Flame Spread Index:**
      1) **ASTM E84, less than 25; fire retardant additives used only in structural layer.**
      2) **Structural wall resin shall contain a minimum of 3 percent antimony trioxide to achieve required flame spread index.]**
   f. Add ultraviolet absorbers to surfacing resin to improve weather resistance.
   g. Color:
      1) Use no dyes, pigments, or colorants **[D: , except in exterior gel coat]**.
      2) Exterior gel coat shall be **[E: white] [F: manufacturer's standard] [G:]**.
3. Reinforcement:
   a. Veil: Chemical surfacing mat, **[H: Type C (chemical) glass veil] [I: Nexus surface veil] [J: carbon veil]**.
   b. Chopped Strand Mat: Type E glass, minimum 1-1/2 ounces per square foot, with silane finish and styrene soluble binder.
   c. Continuous Roving for Chopper Gun Spray-Up: Type E glass.
   d. Woven Roving: Type E glass, nominal 24 ounces per square yard, 4 by 5 weave, with silane type finish.
4. Laminate:
   a. Inner Surface (Veil):
      1) Resin rich, veil reinforced, 10 mils to 20 mils thick.
      2) Use no additives.
      3) Finish and binder compatible with lay-up resin.
      4) Reinforcement Content: Not more than 20 percent.
   b. Interior (Corrosion) Layer:
      1) Resin rich, at least two plies of chopped strand mat, nominal 100 mils to 120 mils thick.
      2) Use no additives.
      3) Construct interior layer of resin reinforced with at least two plies of chopped strand mat backing the veil.
      4) Reinforcement Content: 25 plus or minus 5 percent.
   c. Exterior (Structural) Layer:
      1) Resin with mat, cloth, woven roving or chopped strand glass reinforcement.

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2) Enough resin present to prevent surface fiber show.
3) Exterior surface relatively smooth, with no exposed fibers or sharp projections.

d. Outer Surface (Gel Coat):
1) Resin rich.
2) 10 mils to 20 mils thick.

e. Wall Thickness: As required for equipment structural integrity, but no less than 3/16 inch.

C. Housing:

1. Windband: FRP construction, finished with smooth edge.
2. Top Cap: FRP construction, with motor access via quick release latches.
3. Motor completely sealed from exhaust air stream.
4. Motor cooling via air breather tubes.
5. Integral conduit chase for wiring, vinyl coated flexible metal.
6. Drain trough at lowest point of housing.
7. Fan Inlet:
   a. Aerodynamic inlet venturi, FRP construction.
   b. Match wheel inlet shroud.
8. Hardware: **[A: Steel, epoxy coated.] [B: Type 316 stainless steel.]**

D. Wheel:

1. **[A: Aluminum construction, fully welded, epoxy coated.] [B: Polypropylene.]**
2. Backward inclined centrifugal, nonoverloading type.
3. Machined, cast aluminum hub.
4. Matched to housing inlet venturi.

E. Shaft, Bearings, Drive:

1. Shaft:
   a. Turned, ground, and polished Type 316 stainless steel.
   b. Keyed for sheave installation.
2. Bearings:
   a. Grease lubricated, precision antifriction ball, self-aligning, pillow block style.
   b. Selected for average life (ABMA 9 L_{50}) of not less than 200,000 hours' operation at maximum cataloged operating speed.
   c. Terminate with zerk fittings.
3. Drives:
   a. In accordance with Paragraph Fan Drives.
   b. Factory set to specified fan revolutions per minute.
   c. Type: **[A: Belt or direct, as indicated in Equipment Schedule.] [B: Belt.] [C: Direct.]**

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F. Accessories: Provide **[A: as scheduled on Equipment Schedule.] [B: as follows:]**

1. Gravity Backdraft Damper: Gravity operation, adjustable counterweight, and aluminum construction.
2. Motorized Damper: Aluminum frame, aluminum blades, aluminum hinge pins with nylon bushings, **[C: 120V] [D: 24V]** operator.
3. Bird Screen: Aluminum construction, PVC encapsulated.
4. Roof Curb:
   a. Factory fabricated, **[E: galvanized steel] [F: aluminum] [G: FRP]** construction.
   b. **[H: With] [I: Without]** damper tray.
   c. Sloped to match roof pitch, and to provide level top.
   d. Height Above Finished Roof: **[J: 12 inches.] [K: As scheduled.]**
   e. Mitered continuous welded corner seams.
   f. Pressure-treated wood nailer.
   g. Insulation: Minimum 1-1/2 inches thick, 3 pounds per cubic foot density, rigid mineral fiberboard insulation with metal liner.
5. Disconnect: Factory installed, nonfused, NEMA Type **[L: 3R] [M: 4X] [N: as scheduled]**.
6. Bearing Lubrication Lines:
   a. Extended to outside of fan housing.
   b. Type 316 stainless steel construction.
   c. Terminate with zerk fittings.
7. Spark Resistant Construction:
   a. AMCA 99-0401 Type **[O: A] [P: B] [Q: C] [R: as scheduled]**.
   b. Graphite impregnated in housing.
   c. Static grounding.

G. Manufacturers and Products:

1. Twin City; Whirlout Model WA/WAB.
2. Composite Fan Technology; Corro-Vent Model CVC.

2.11 ROOF FAN, HOODED PROPELLER, FILTERED SUPPLY

A. General:

1. Factory-assembled roof mounted supply air fan; including housing, hood, filters, propeller fan wheel, drive assembly, motor and accessories.
2. Bearing AMCA Certified Ratings Seal for sound and air performance.

B. Housing:

1. Minimum 16-gauge **[A: painted steel] [B: galvanized steel] [C: aluminum]** construction.

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2. Integral formed venturi orifice.
3. Continuously welded corners.
4. Bolted to frame.
5. Frame:
    a. Minimum 14-gauge steel construction.
    b. Continuously welded joints.
    c. Reinforced motor base plate.

C. Hood:

1. Arched panel type with interlocking ribs.
2. Same material as housing.
3. Supported by heavy gauge galvanized steel frame.
4. Removable for fan access, bolted to top of fan housing.
5. Sized to allow no more than 500 fpm air intake face velocity.
6. Insulation: Fiberglass, **[A: 1/2] [B: 1]-**inch thickness, attached to underside of hood.

D. Filters and Frames:

1. Metal Mesh Type:
    a. Washable, 4-mesh **[A: zinc electroplated steel] [B: aluminum]** screen media.
    b. Thickness: 2 inches.
    c. Minimum **[C: 25] [D:]** percent dust spot efficiency in accordance with ASHRAE 52.2.
2. Frames:
    a. Located on underside of hood perimeter, permanent reusable.
    b. **[E: 16-gauge steel] [F: Aluminum]** holding frame, retainer, and sealer frame.
    c. To allow removal of filters without removal of hood.
3. Manufacturers:
    a. Camfil Farr.
    b. American Air Filter.
    c. Viledon.

E. Curb Base:

1. Same material as housing.
2. Minimum 18 inches tall.
3. **[A: Access door, for service of backdraft damper, motorized damper, insect screen.]**
4. Rubber stripping attached to underside of fan curb cap.
5. Lifting lugs, welded to each corner.

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F. Wheel:

1. Hub: Cast aluminum.
2. Propeller: Cast aluminum airfoil blade design.
3. Wheel assembly attached to fan shaft with split taper lock bushing.

G. Shaft, Bearings, Drive:

1. Shaft:
   a. Turned, ground, and polished carbon steel.
   b. Keyed for sheave installation.
   c. Zinc-phosphate coated and oil emulsion-dipped.
2. Bearings:
   a. Grease lubricated, precision antifriction ball, self-aligning, pillow block style.
   b. Selected for average life (ABMA 9 L_{50}) of not less than 200,000 hours operation at maximum cataloged operating speed.
   c. Terminate with zerk fittings.
3. Drives:
   a. In accordance with Paragraph Fan Drives.
   b. Factory set to specified fan revolutions per minute.
   c. Type: **[A: As scheduled in Equipment Schedule.] [B: Belt.] [C: Direct.]**

H. Accessories: Provide **[A: as scheduled in Equipment Schedule.] [B: as follows:]**

1. Gravity Backdraft Damper: Gravity operation, adjustable counterweight, and aluminum construction.
2. Motorized Damper: Aluminum frame, aluminum blades, aluminum hinge pins with nylon bushings, **[C: 120V] [D: 24V]** operator.
3. Insect Screen:
   a. **[E: Galvanized steel] [F: Aluminum]** frame.
   b. Aluminum mine mesh screen.
4. Bird Screens: Aluminum construction.
5. Roof Curb:
   a. Factory fabricated, **[G: galvanized steel] [H: aluminum]** construction.
   b. **[I: With] [J: Without]** damper tray.
   c. Sloped to match roof pitch, and to provide level top.
   d. Height Above Finished Roof: **[K: 12 inches.] [L: As scheduled.]**
   e. Mitered continuous welded corner seams.
   f. Pressure-treated wood nailer.
   g. Insulation: Minimum 1-1/2 inches thick, 3 pounds per cubic foot density, rigid mineral fiberboard insulation with metal liner.

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6. Disconnect: Factory installed, nonfused, NEMA **[M: 3R] [N: 4] [O: as scheduled]**.
7. Bearing Lubrication Lines:
    a. Extended to outside of fan housing.
    b. Type 316 stainless steel construction.
    c. Terminate with zerk fittings.
8. Filter Pressure Gauge:
    a. Each filter bank shall be furnished with **[P: magnehelic filter gauge (Dwyer Series 2000)] [Q: air filter gauge (Dwyer Mark 25)] [R: inclined manometer (DWYER 250 AF)]**.
    b. With adjustable signal flag.
9. Inlet Screen: Removable 1-inch mesh screen of coated steel construction over exposed inlets.
10. Corrosion Protection Coating:
    a. Provide factory-applied corrosion protection coating on these fan components:
        1) Wheel.
        2) Housing.
        3) Accessories.
        4) Interior surfaces in contact with airstream.
    b. **[S: Coating system shall be [T: baked enamel] [U: baked polyester] [V: air-dry epoxy] [W: baked epoxy] [X: air dry phenolic] [Y: baked phenolic] [Z: baked epoxy phenolic] [A: as scheduled in fan Equipment Schedule], and shall be in accordance with Article Corrosion Protection Coating.]**
    c. **[B: Coating system shall be in accordance with Section 09 90 00, Painting and Coating.]**

I. Manufacturers and Products:

1. Aerovent: Model FSR.
2. Greenheck; Model R (Direct Drive); RB (Belt Drive).
3. Cook; Model HEF-D.

2.12 ROOF GRAVITY VENTILATOR, LOUVERED

A. General: Factory-assembled louvered exhaust or gravity relief vent; including housing and accessories, suitable for roof mounting.

B. Housing:

1. Construction:
    a. Rectangular, tiered extruded aluminum construction, with welded miter cut joints, 12-gauge minimum thickness.
    b. Louvered on all four sides.
    c. Aluminum support structure, 8-gauge minimum thickness.

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2. Base:
    a. Reinforced and braced.
    b. Integral snow and storm baffle.
    c. Minimum panel thickness, 12 gauge.
    d. Miter cut continuously welded curb cap corners.
3. Hood:
    a. Overhang sufficient to provide weatherproof inlet.
    b. Minimum panel thickness, 14 gauge.
    c. Anticondensate insulation coating inside hood.

C. Accessories: Provide **[A: as scheduled in Equipment Schedule.] [B: as follows:]**

1. Gravity Backdraft Damper: Gravity operation, adjustable counterweight, aluminum construction.
2. Motorized Damper: Aluminum frame, aluminum blades, aluminum hinge pins with nylon bushings, **[C: 120] [D: 12]**–volt operator.
3. Bird Screen: Aluminum construction.
4. Roof Curb:
    a. Factory fabricated.
    b. **[E: With] [F: Without]** damper tray.
    c. Sloped to match roof pitch, and to provide level top.
    d. Height Above Finished Roof: **[G: 12 inches.] [H: As scheduled.]**
    e. **[I: Galvanized steel] [J: Aluminum]** construction.
    f. Mitered, continuous welded corner seams.
    g. Pressure-treated wood nailer.
    h. Insulation: Minimum 1-1/2 inches thick, 3 pounds per cubic foot density, rigid mineral fiberboard insulation with metal liner.
5. Inlet Screen: Removable 1-inch mesh screen of coated steel construction over exposed inlets.
6. Corrosion Protection Coating:
    a. Provide factory-applied corrosion protection coating on these fan components:
        1) Housing.
        2) Accessories.
        3) Interior surfaces in contact with airstream.
    b. **[K: Coating system shall be [L: baked enamel] [M: baked polyester] [N: air-dry epoxy] [O: baked epoxy] [P: air-dry phenolic] [Q: baked phenolic] [R: baked epoxy phenolic] [S: as scheduled in fan Equipment Schedule]**, **and shall be in accordance with Article Corrosion Protection Coating.]**
    c. **[T: Coating system shall be in accordance with Section 09 90 00, Painting and Coating.]**

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D. Manufacturers and Products:

1. Cook; Model TRE.
2. ACME; Model LEV (exhaust); Model LIV (intake).
3. Greenheck; Model WRH (relief); Model WIH (intake)

2.13 UTILITY BLOWER, CENTRIFUGAL SWSI, FIBERGLASS

A. General:

1. Factory-assembled utility blower; including housing, fan wheel, drive assembly, motor and accessories.
2. Fiberglass Construction: In accordance ASTM D4167.
3. Suitable to convey air at temperatures up to 250 degrees F.
4. Fan Performance: AMCA 99-2408 Class **[A: I] [B: II] [C: III] [D: as scheduled]**.
5. Airstream Hardware: Type 316 stainless steel.

B. Fiberglass Material:

1. Construction: Resin reinforced fiber cloth and mat.
2. Resin:
   a. Vinyl ester or other qualified thermosetting resin.
   b. Selected by fabricator, subject to approval by Engineer and suitable for intended service with no fillers or thixotropic agents.
   c. Premium grade and corrosion resistant.
   d. Structural wall resin may be of different chemical resistance, subject to conditions of service and approval by Engineer.
   e. **[A: Flame Spread Index:**
      1) **ASTM E84, less than 25; fire retardant additives used only in structural layer.**
      2) **Structural wall resin shall contain a minimum of 3 percent antimony trioxide to achieve required flame spread index.]**
   f. For outdoor locations, add ultraviolet absorbers to surfacing resin to improve weather resistance.
   g. Color:
      1) Use no dyes, pigments, or colorants **[B: , except in exterior gel coat]**.
      2) Exterior gel coat shall be **[C: white] [D:]**.
   h. For interior locations, final coat shall be factory-applied intumescent coating to achieve designated results for low smoke development.
3. Reinforcement:
   a. Veil: Chemical surfacing mat, **[E: Type C (chemical) glass veil] [F: Nexus Surface Veil] [G: carbon veil]**.

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b. Chopped Strand Mat: Type E glass, minimum 1-1/2 ounces per square foot, with silane finish and styrene soluble binder.
c. Continuous Roving for Chopper Gun Spray-Up: Type E glass.
d. Woven Roving: Type E glass, nominal 24 ounces per square yard, 4 by 5 weave, with silane type finish.

4. Laminate:
   a. Inner Surface (Veil):
      1) Resin rich, veil reinforced, 10 mils to 20 mils thick.
      2) Use no additives.
      3) Finish and binder compatible with lay-up resin.
      4) Reinforcement Content: Not more than 20 percent.
   b. Interior (Corrosion) Layer:
      1) Resin rich, at least two plies of chopped strand mat, nominal 100 mils to 120 mils thick.
      2) Use no additives.
      3) Construct interior layer of resin reinforced with at least two plies of chopped strand mat backing the veil.
      4) Reinforcement Content: 25 plus or minus 5 percent.
   c. Exterior (Structural) Layer:
      1) Resin with mat, cloth, woven roving or chopped strand glass reinforcement.
      2) Enough resin present to prevent surface fiber show.
      3) Exterior surface relatively smooth, with no exposed fibers or sharp projections.
   d. Wall Thickness: As required for equipment structural integrity, but no less than 3/16 inch.

C. Housing:

1. Material: Fiberglass.
2. Construction:
   a. Curved scroll configuration.
   b. Integral flanges to ensure housing concentricity and housing strength.
   c. Flanged outlet to permit duct connection.
   d. Drain connection located at lowest point of fan housing.
   e. Inlet:
      1) Die-formed bell mouth of fiberglass construction.
      2) Fiberglass supports.
      3) Bolted to housing to permit wheel removal.
   f. Shaft Seal: Viton construction, located at shaft penetration of housing.
3. Base/Pedestal: All-welded heavy gauge **[A: steel] [B: Type 316 stainless steel]**.

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D. Wheel:

1. Material: Fiberglass.
2. Fan wheel speed not to exceed 90 percent of manufacturer's listed safe fan speed.
3. Centrifugal, one-piece, nonoverloading, **[A: radial blade type] [B: backward inclined airfoil blade type] [C: blade type as scheduled]**.
4. Wheel hub permanently bonded to shaft and completely encapsulated in fiberglass.

E. Shaft, Bearings, Drive:

1. Shafts:
   a. Turned, ground, and polished Type 304 stainless steel.
   b. Ends drilled and tapped for wheel installation.
   c. Keyed for sheave installation.
2. Bearings:
   a. Grease lubricated, precision antifriction ball, self-aligning type.
   b. Mounted in cast iron pillow block housing.
   c. Selected for average life (ABMA 9 L_{50}) of not less than 200,000 hours operation at maximum cataloged operating speed.
3. Drives:
   a. In accordance with Paragraph Fan Drives.
   b. Factory set to specified fan revolutions per minute.
   c. Type: **[A: Belt or direct, as indicated in Equipment Schedule.] [B: Belt.] [C: Direct.]**
   d. Arrangement: **[D: As scheduled in Equipment Schedule.] [E: Arrangement 10.] [F: Arrangement 9.] [G: Arrangement 4.] [H: Arrangement 1.]**

F. Accessories: Provide **[A: as scheduled in Equipment Schedule.] [B: as follows:]**

1. Housing Access Doors: Bolted and gasketed.
2. Curb Base: Molded one-piece fiberglass, seamless construction.
3. Disconnect: Factory installed, nonfused, NEMA Type **[C: 3R] [D: 4X] [E: as scheduled]**.
4. Flanged Inlet: Heavy fiberglass construction, factory drilled and flanged.
5. Shaft Seal: Fiberglass and neoprene construction, located at shaft penetration of housing.
6. Belt Guard: OSHA type, carbon steel sheet metal, for complete coverage of belts and sheaves.
7. Shaft and Bearing Guard: Carbon steel sheet metal for complete coverage of shaft and bearings.

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8. Motor and Drive Cover:
    a. Factory fabricated; OSHA type.
    b. Carbon steel sheet metal construction.
    c. Vented, openings sufficient size for proper motor cooling.
9. Inlet Screen: Removable 1-inch mesh screen of coated steel construction over exposed inlets.
10. Unitary Subbase:
    a. Structural metal subbase, same material as fan housing.
    b. Bolted to bottom of fan base/pedestal.
    c. Drilled for field installation of vibration isolators.
11. Spark Resistant Construction:
    a. Carbon fiber veil impregnated in housing and wheel fiberglass resin corrosion barrier.
    b. Static grounding.
    c. Classification: AMCA 99-0401 Type **[F: A] [G: B] [H: C] [I: as scheduled]**.
12. Corrosion Protection Coating:
    a. Provide factory-applied corrosion protection coating on fan steel components.
    b. **[J: Coating system shall be [K: baked enamel] [L: baked polyester] [M: air-dry epoxy] [N: baked epoxy] [O: air dry phenolic] [P: baked phenolic] [Q: baked epoxy phenolic] [R: as scheduled in fan Equipment Schedule], and shall be in accordance with Article Corrosion Protection Coating.]**
    c. **[S: Coating system shall be in accordance with Section 09 90 00, Painting and Coating.]**

G. Manufacturers and Products:

1. Aerovent; Model RBF.
2. New York Blower; Model FE.
3. Hartzell; Series 41.

2.14 UTILITY BLOWER, CENTRIFUGAL SWSI, HEAVY DUTY

A. General:

1. Factory-assembled utility blower; including housing, fan wheel, drive assembly, motor, and accessories.
2. Suitable to convey air at temperatures up to 250 degrees F.
3. Fan Performance: AMCA 99-2408 Class **[A: I] [B: II] [C: III] [D: as scheduled]**.
4. Bearing AMCA Certified Ratings Seal for sound and air performance.

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B. Housing:

1. Material: **[A: Steel.] [B: Aluminum.] [C: Type 304 stainless steel.] [D: Type 316 stainless steel.]**
2. Construction:
   a. Curved scroll configuration, with continuous seam welding and side angle reinforcement.
   b. Lifting lugs welded to housing.
   c. Flanged and drilled outlet to permit duct connection.
   d. Drain connection located at lowest point of fan housing.
   e. Inlet: Spun-formed aerodynamic bell mouth.
3. Base/Pedestal: All-welded heavy gauge **[A: steel] [B: Type 316 stainless steel]**.

C. Wheel:

1. Centrifugal, one-piece, nonoverloading, **[A: radial blade type] [B: backward inclined flat blade type] [C: backward inclined airfoil blade type] [D: blade type as scheduled]**.
2. Fan wheel speed not to exceed 90 percent of manufacturer's listed safe fan speed.
3. Material: **[E: Steel.] [F: Aluminum.] [G: Type 304 stainless steel.] [H: Type 316 stainless steel.]**
4. Attached to fan shaft with split taper lock bushing.

D. Shaft, Bearings, Drive:

1. Shafts:
   a. Turned, ground, and polished steel.
   b. Ends drilled and countersunk for tachometer readings.
   c. Keyed for sheave installation.
2. Bearings:
   a. Grease lubricated, precision antifriction ball, self-aligning type.
   b. Mounted in cast iron pillow block housing.
   c. Selected for average life (ABMA 9 L_{50}) of not less than 200,000 hours operation at maximum cataloged operating speed.
3. Drives:
   a. In accordance with Paragraph Fan Drives.
   b. Factory set to specified fan revolutions per minute.
   c. Type: **[A: Belt or direct, as indicated in Equipment Schedule.] [B: Belt.] [C: Direct.]**
   d. Arrangement: **[D: As scheduled in Equipment Schedule.] [E: Arrangement 9.] [F: Arrangement 10.] [G: Arrangement 4.] [H: Arrangement 1.]**

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E. Accessories: Provide **[A: as scheduled in Equipment Schedule.] [B: as follows:]**

1. Housing Access Doors: Bolted and gasketed.
2. Disconnect: Factory installed, nonfused, NEMA Type **[C: 3R] [D: 4X] [E: as scheduled]**.
3. Flanged Inlet: Heavy gauge construction, factory drilled and flanged.
4. Shaft Seal: Viton construction, located at shaft penetration of housing.
5. Belt Guard: OSHA type, sheet metal construction same material as fan housing, for complete coverage of belts and sheaves.
6. Shaft and Bearing Guard: Sheet metal construction same material as fan housing, for complete coverage of shaft and bearings.
7. Motor and Drive Cover:
   a. Factory fabricated; OSHA type.
   b. Sheet metal construction, same material as fan housing.
   c. Vented, openings sufficient size for proper motor cooling.
8. Inlet Guard: Spiral wire type, OSHA approved, removable, same material as fan housing.
9. Unitary Subbase:
   a. Structural metal subbase, same material as fan housing.
   b. Bolted to bottom of fan base/pedestal.
   c. Drilled for field installation of vibration isolators.
10. Spark Resistant Construction Classification: AMCA 99-0401 Type **[F: A] [G: B] [H: C] [I: as scheduled]**.
11. Corrosion Protection Coating:
    a. Provide factory-applied corrosion protection coating on these fan components:
       1) Wheel (or propeller).
       2) Housing.
       3) Accessories.
       4) Interior surfaces in contact with airstream.
    b. **[J: Coating system shall be [K: baked enamel] [L: baked polyester] [M: air-dry epoxy] [N: baked epoxy] [O: air dry phenolic] [P: baked phenolic] [Q: baked epoxy phenolic] [R: as scheduled in fan Equipment Schedule], and shall be in accordance with Article Corrosion Protection Coating.]**
    c. **[S: Coating system shall be in accordance with Section 09 90 00, Painting and Coating.]**

F. Manufacturers and Products:

1. Aerovent; Model BI.
2. New York Blower; Acoustafoil/PLR.
3. Cook; CP Series.

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2.15 WALL FAN, CENTRIFUGAL

A. General:

1. Factory-assembled centrifugal wall fan; including housing, fan wheel, drive assembly, motor and accessories.
2. Bearing AMCA Certified Ratings Seal for sound and air performance.

B. Housing:

1. Construction: Spun-formed aluminum, minimum 16-gauge marine alloy.
2. Windband: Finish with rolled bead.
3. Cap: Motor access via quick release latches.
4. Motor completely sealed from exhaust air stream.
5. Motor cooling via air breather tubes.
6. Integral conduit chase for wiring.
7. Fan Inlet:
   a. Full inlet cone of aluminum construction.
   b. Match inlet shroud.
8. Wall Flange: Aluminum construction, with prepunched key slot holes.

C. Fan Wheels:

1. Aluminum construction, backward inclined centrifugal, nonoverloading type.
2. Machined, cast aluminum hub.
3. Matched to deep spun inlet venturi.

D. Shaft, Bearings, Drive:

1. Shaft:
   a. Turned, ground, and polished carbon steel.
   b. Keyed for sheave installation.
   c. Zinc-phosphate coated and oil emulsion-dipped.
2. Bearings:
   a. Grease lubricated, precision antifriction ball, self-aligning, pillow block style.
   b. Selected for average life (ABMA 9 L_{50}) of not less than 200,000 hours operation at maximum cataloged operating speed.
   c. Terminate with zerk fittings.
3. Drives:
   a. In accordance with Paragraph Fan Drives.
   b. Factory set to specified fan revolutions per minute.
   c. Type: **[A: Belt or direct, as indicated in Equipment Schedule.] [B: Belt.] [C: Direct.]**

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E. Accessories: Provide **[A: as scheduled in Equipment Schedule.] [B: as follows:]**

1. Gravity Backdraft Damper: Gravity operation, adjustable counterweight, aluminum construction.
2. Motorized Damper: Aluminum frame, aluminum blades, aluminum hinge pins with nylon bushings, **[C: 120V] [D: 24V]** operator.
3. Bird Screen: Aluminum construction.
4. Disconnect: Factory installed, nonfused, NEMA Type **[E: 3R] [F: 4X] [G: as scheduled]**.
5. Bearing Lubrication Lines:
   a. Extended to outside of fan housing.
   b. Type 316 stainless steel construction.
   c. Terminate with zerk fittings.
6. Spark Resistant Construction: Classification: AMCA 99-0401 Type **[H: A] [I: B] [J: C] [K: as scheduled]**.
7. Corrosion Protection Coating:
   a. Provide factory-applied corrosion protection coating on these fan components:
      1) Wheel.
      2) Housing.
      3) Accessories.
      4) Interior surfaces in contact with airstream.
   b. **[L: Coating system shall be [M: baked enamel] [N: baked polyester] [O: air-dry epoxy] [P: baked epoxy] [Q: air dry phenolic] [R: baked phenolic] [S: baked epoxy phenolic] [T: as scheduled in fan Equipment Schedule], and shall be in accordance with Article Corrosion Protection Coating.]**
   c. **[U: Coating system shall be in accordance with Section 09 90 00, Painting and Coating.]**

F. Manufacturers and Products:

1. Cook; Model ACWD (Direct Drive); ACWB (Belt Drive).
2. Greenheck; Model CW (Direct Drive); CWB (Belt Drive).
3. ACME; Model PDU (Direct Drive); PNU (Belt Drive).
4. Aerovent; Model AWX.
5. Twin City; Model TCWX.

2.16 WALL FAN, PROPELLER, HEAVY DUTY

A. General: Factory-assembled wall propeller fan; including housing, propeller, drive assembly, motor and accessories.

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B. Housing:

1. Material: Metal components constructed from **[A: steel] [B: aluminum] [C: materials as indicated in Equipment Schedule]**.
2. Panel:
   a. Minimum 14-gauge sheet metal construction.
   b. Integral formed venturi orifice.
   c. Continuously welded corners.
   d. Bolted to frame.
3. Frame:
   a. Minimum 14-gauge metal construction.
   b. Continuously welded joints.
   c. Reinforced motor baseplate.

C. Propeller:

1. Cast aluminum construction.
2. Hub keyed and mechanically locked to shaft.

D. Shaft, Bearings, Drive:

1. Shaft:
   a. Turned, ground, and polished carbon steel.
   b. Keyed for sheave installation.
2. Bearings:
   a. Grease lubricated, precision antifriction ball, self-aligning, sealed pillow block style.
   b. Mounted in cast iron pillow block housing.
   c. Selected for average life (ABMA 9 L_{50}) of not less than 200,000 hours operation at maximum cataloged operating speed.
3. Drives:
   a. In accordance with Paragraph Fan Drives.
   b. Factory set to specified fan revolutions per minute.
   c. Type: **[A: Belt or direct, as indicated in Equipment Schedule.] [B: Belt.] [C: Direct.]**

E. Accessories: Provide **[A: as scheduled in Equipment Schedule.] [B: as follows:]**

1. Disconnect: Factory-installed, nonfused, NEMA Type **[C: 12] [D: 4X] [E: as scheduled]**.
2. Propeller-Side Guard: Galvanized steel construction.
3. Motor-Side Guard: Galvanized steel construction.
4. Weather Hood:
   a. Heavy-gauge galvanized steel construction, to match fan and accessory size.
   b. Galvanized steel expanded metal bird screen.

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5. Wall Housing:
    a. Allows fan mounting on interior or exterior wall.
    b. Heavy-gauge galvanized steel construction.
6. Shutters, Gravity Operated:
    a. Welded **[F: steel] [G: aluminum]** frame.
    b. Extruded aluminum blades.
    c. Felt edge seals.
    d. Oil impregnated bronze bushings.
    e. Reverse flange for building exterior mounting. Standard flange for indoor mounting.
7. Shutters, Motor Operated:
    a. Welded **[H: steel] [I: aluminum]** frame.
    b. Extruded aluminum blades.
    c. Stainless steel edge seals.
    d. Oil impregnated bronze bushings.
    e. 120-volt spring return damper actuator with end switch.
    f. Reverse flange for building exterior mounting. Standard flange for indoor mounting.
8. Spark Resistant Construction:
    a. Nonferrous blade assembly.
    b. Classification: AMCA 99-0401 Type **[J: A] [K: B] [L: C] [M: as scheduled]**.
9. Panel Fan Boot:
    a. To adapt fan panel to wall louver.
    b. Size to suit louver dimension as shown on Drawings or indicated in Specifications.
    c. Sheet metal construction, same material as fan housing.
10. Corrosion Protection Coating:
    a. Provide factory-applied corrosion protection coating on these fan components:
        1) Housing.
        2) Accessories.
        3) Interior surfaces in contact with airstream.
    b. **[A: Coating system shall be [B: baked enamel] [C: baked polyester] [D: air-dry epoxy] [E: baked epoxy] [F: air dry phenolic] [G: baked phenolic] [H: baked epoxy phenolic] [I: as scheduled in fan Equipment Schedule]**, **and shall be in accordance with Article Corrosion Protection Coating.]**
    c. **[J: Coating system shall be in accordance with Section 09 90 00, Painting and Coating.]**

F. Manufacturers and Products:

1. Aerovent; Model DDP (Direct); Model BP (Belt).
2. New York Blower; Model NYC.
3. Hartzell; Model Series 02.

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2.17 FILTER HOUSING

A. General:

1. Air filtration section, complete with filter media and filter racks.
2. Designed for static pressure ranges of **[A: minus 3] [B:]** inches WC to **[C: plus 3] [D:]** inches WC.
3. Design temperature not to exceed 200 degrees F.
4. Leakage at rated airflow upstream to downstream of filter frame shall be less than 1 percent at 3 inches WC. Leakage in to or out of housing shall be less than 0.5 percent at 3 inches WC.
5. **[E: V-Bank housings to be used for airflow rates 1,000 acfm or greater.]**
6. **[F: Flat panel housings to be used for airflow rates less than 1,000 acfm.]**
7. Flanged units suitable for installation in a duct and for space indicated.
8. Housing to fit standard nominal filter sizes, either 24 inches by 24 inches or 24 inches by 12 inches.
9. Maximum 500 fpm face velocity across filters.
10. Filters arranged in a suitable leak-tight frame and enclosure.

B. Housing:

1. Permanent reusable, side-loading **[A: 16-gauge galvanized or aluminized steel] [B: aluminum] [C: Type 304 stainless steel]** frame and retainer.
2. Housing to be supported on a structural steel frame.
3. Doors:
   a. Provide hinged, quick-opening doors for access, service and removal of filters.
   b. Side access doors to be locked closed and opened without use of tools.
   c. Plastic door hardware to be made of UV-resistant materials.
   d. Provide doors on **[D: one] [E: both]** sides of unit. **[F: See Drawings for access door location.]**
4. Provide upstream and downstream outwardly turned flanges of same material as housing.
5. Provide gaskets for filter tracks and doors for positive sealing. Filter track gaskets to be replaceable.
6. Treat cabinet and accessory surfaces inside and out with rust-inhibitive surface coating and painted with prime and finish coat of machinery enamel.
7. **[G: Provide weatherproof housing suitable for outdoor/rooftop installation. Silicone seal metal-to-metal joints for watertight seams.]**

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8. **[H: Inside surfaces of housing insulated with 1-inch thick, 1-1/2-pound density insulation on outdoor units.]**
9. Provide upstream and downstream static pressure taps, with 1/4-inch diameter tube connections for measuring pressure drop across filters.
10. Provide lifting lugs suitable for lifting and assembled housing and filters.
11. Provide housing hanging brackets of same material as housing suitable to supporting complete filter housing assembly.

C. Filters:

1. Filter Media Thickness: **[A: 2] [B: 4] [C: 6 (flat bank only)]** inches.
2. Arrangement: **[D: Angled V-bank.] [E: Vertical flat bank.]**
3. Pleated panel disposable filters. Nonwoven reinforced **[F: cotton/poly (for MERV 7)] [G: 100 percent synthetic (for MERV 8)]** fabric media with a metal support grid and heavy duty beverage board enclosing frame. Minimum MERV **[H: 7] [I: 8] [J:]** efficiency per ASHRAE 52.2. Minimum **[K: 30] [L:]** percent dust spot efficiency.
4. Initial clean filter resistance of 0.28-inch WC. Maximum filter resistance of 1-inch WC.
5. **[M: UL Class 2 filter.]**

D. Accessories:

1. Filter Pressure Gauge: Furnish each filter bank with **[A: magnehelic gauge (Dwyer Series 2000)] [air filter gauge (Dwyer Mark 25)] [B: inclined manometer (Dwyer 250 AF)]** with connecting polypropylene tubing and adjustable signal flag.

E. Manufacturers and Products:

1. **[A: V-Bank Filter Housings:**
   a. **Flanders Precisionaire; Sureflo.**
   b. **Tri-Dim Filter Corp.; Tri-Met VB.**
   c. **Airguard; Model VB.]**
2. **[B: Flat Panel Filter Housings:**
   a. **Camfil Farr; 4P Glid Pack.**
   b. **Flanders Precisionair; Superpleat.**
   c. **Tri-Dim Filter Corp.; Tri-Met FB.**
   d. **Airguard; Model FB.]**

2.18 CORROSION PROTECTION COATING

A. General:

1. Factory-applied corrosion protection coating for application to fan components and accessories, where required by this section.

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2. Quality Control:
    a. Verify dry film thickness before final baking.
    b. Finished coating system shall be free from voids, checks, cracks, and blisters.
3. Surface Cleaning: Clean parts to be coated as follows:
    a. Immerse parts in heated cleaning solution to remove lubricants, machining oils, and residual factory contamination.
    b. Follow with immersion in potable water bath to neutralize and remove cleaning solution.
    c. Chemical Pretreatment: Immerse parts in heated chemical solution, iron phosphate for steel, clear/yellow chromate for aluminum.

B. Baked Enamel:

1. Material: Alkyd modified urea-melamine single component baking enamel.
2. Surface Preparation: Clean surface to SSPC SP 3.
3. Application: Standard air-pressurized spray equipment.
4. Curing: Oven baked at a metal temperature not to exceed 300 degrees F.
5. Finished Thickness: 1-mil to 2-mil dry film thickness.
6. Performance: Coating shall meet or exceed following criteria:
    a. Impact Resistance: 10-inch pounds, ASTM D2794 test method.
    b. Pencil Hardness: 2H, ASTM D3363 test method.
    c. Service Temperature: Maximum 230 degrees F, continuous.

C. Baked Polyester:

1. Material: Polyester.
2. Surface Preparation: Sandblast surface to SSPC SP 5.
3. Application: Electrostatic spray.
4. Curing: Oven baked at a metal temperature not to exceed 400 degrees F.
5. Finished Thickness: 1.5-mil to 2.5-mil dry film thickness.
6. Performance: Coating shall meet or exceed following criteria:
    a. Salt Spray Test: Minimum 1,000-hour duration, ASTM B117 test method.
    b. Humidity Resistance: Minimum 1,000-hour duration, ASTM D2247 test method.
    c. Impact Resistance: 100-inch pounds, ASTM D2794 test method.
    d. Pencil Hardness: 2H, ASTM D3363 test method.
    e. Service Temperature: Maximum 230 degrees F, continuous.

D. Air-Dry Epoxy:

1. Material: Two-part catalyzed epoxy.
2. Surface Preparation: Clean surface to SSPC SP 3.

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3. Application: Standard air-pressurized spray equipment.
4. Curing: Air dry.
5. Finished Thickness: 4-mil to 6-mil dry film thickness.
6. Performance: Coating shall meet or exceed following criteria:
    a. Salt Spray Test: Minimum 1,500-hour duration, ASTM B117 test method.
    b. Pencil Hardness: H-2H, ASTM D3363 test method.
    c. Service Temperature: Maximum 150 degrees F, continuous.

E. Baked Epoxy:

1. Material: Epoxy.
2. Surface Preparation: Sandblast surface to SSPC SP 10.
3. Application: Electrostatic spray.
4. Curing: Oven baked at a metal temperature not to exceed 400 degrees F.
5. Finished Thickness: 2.5-mil to 3.5-mil dry film thickness.
6. Performance: Coating shall meet or exceed following criteria:
    a. Salt Spray Test: Minimum 1,000-hour duration, ASTM B117 test method.
    b. Humidity Resistance: Minimum 1,000-hour duration, ASTM D2247 test method.
    c. Impact Resistance: 100 inch pounds, ASTM D2794 test method.
    d. Pencil Hardness: 2H, ASTM D3363 test method.
    e. Service Temperature: Maximum 230 degrees F, continuous.

F. Air Dry Phenolic:

1. Material:
    a. Phenolic resin, Heresite VR-500 Series or equal.
    b. For outdoor applications, apply an UV resistant topcoat, Heresite UC-5500 or equal.
2. Surface Preparation: Sandblast surface to SSPC SP 6.
3. Application: Standard air-pressurized spray equipment.
4. Curing: Air dry.
5. Finished Thickness: 4-mil to 6-mil dry film thickness.
6. Performance: Coating shall meet or exceed following criteria:
    a. Salt Spray Test: Minimum 500-hour duration, ASTM B117 test method.
    b. Humidity Resistance: Minimum 500-hour duration, ASTM D2247 test method.
    c. Service Temperature: Maximum 180 degrees F, continuous.

G. Baked Phenolic:

1. Material: Phenolic resin, Heresite P-403 or equal.
2. Surface Preparation: Sandblast surface to SSPC SP 5.

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3. Application: Standard air-pressurized spray equipment.
4. Curing: Oven baked at a metal temperature not to exceed 400 degrees F.
5. Finished Thickness: 5-mil to 7-mil dry film thickness.
6. Performance: Coating shall meet or exceed following criteria:
    a. Salt Spray Test: Minimum 1,000-hour duration, ASTM B117 test method.
    b. Humidity Resistance: Minimum 1,000-hour duration, ASTM D2247 test method.
    c. Impact Resistance: 100-inch pounds, ASTM D2794 test method.
    d. Pencil Hardness: 2H, ASTM D3363 test method.
    e. Service Temperature: Maximum 250 degrees F, continuous.

H. Baked Epoxy Phenolic:

1. Material:
    a. Baking cross-linked epoxy-phenolic.
    b. For outdoor applications, apply an UV-resistant topcoat.
2. Surface Preparation: Sandblast surface to SSPC SP 5.
3. Application: Electrostatic or conventional compressed air spray equipment.
4. Curing: Oven baked at a metal temperature not to exceed 400 degrees F.
5. Finished Thickness: 6-mil to 8-mil dry film thickness.
6. Performance: Coating shall meet or exceed following criteria:
    a. Salt Spray Test: Minimum 1,000-hour duration, ASTM B117 test method.
    b. Humidity Resistance: Minimum 1,000-hour duration, ASTM D2247 test method.
    c. Impact Resistance: 160-inch pounds, ASTM D2794 test method.
    d. Pencil Hardness: 3H, ASTM D3363 test method.
7. Service Temperature: Maximum 350 degrees F, continuous.

2.19 MOTORS

A. General:

1. Fan motors shall comply with provisions of Section 26 20 00, Low-Voltage AC Induction Motors.
2. Provide integral self-resetting overload protection on single-phase motors.
3. Motors for fans specified for use with variable frequency drives shall be inverter duty type.
4. Motors shall not operate into service factor in any case.

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B. Motor requirements shall be as follows, unless designated otherwise on Equipment Schedule:

1. Torque Characteristics: Sufficient to accelerate driven loads satisfactorily.
2. Winding Thermal Protection: None.
3. Space Heater: No.
4. Number of Speeds: Single.
5. Number of Windings: One.
6. Motor Efficiency: **[A: Energy efficient.] [B: Premium efficient.]**
7. Shaft Type: Solid, carbon steel.
8. Mounting: As required for fan arrangement.
9. Service Factor: 1.15.

2.20 ACCESSORIES

A. Equipment Identification Plates: Furnish 16-gauge **[A: Type _____]** stainless steel identification plate securely mounted on each separate equipment component **[B: and control panel]** in a readily visible location. Plate shall bear **[C: 3/8] [D: 1/4]**-inch high **[E: engraved] [F: die-stamped]** block type **[G: black enamel filled]** equipment **[H: identification number] [I: and letters]** indicated in this Specification **[J: and as shown on Drawings]**.

B. Lifting Lugs: Furnish suitably attached for equipment assemblies and components weighing over 100 pounds.

2.21 SOURCE QUALITY CONTROL

A. General:

1. Fan shall operate at single stable point as indicated by fan curve. Fans having two potential operating points are not acceptable.
2. Fan and motor combination shall be capable of delivering 110 percent of scheduled air quantity and static pressure. Motor shall not operate into motor service factor in any listed case.
3. Consider drive efficiency in motor selection according to manufacturer’s published recommendation or according to AMCA 203, Appendix L.

B. Testing Provisions:

1. Provide tachometer access holes large enough to accept standard tachometer drive shaft.
2. Center punch fan shaft to accommodate tachometer readings.

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C. Acoustical Levels:

1. Perform noise tests in accordance with AMCA 300 and AMCA 301.
2. Fan sound power levels (dB, Reference 10^{-12} Watts) shall be no greater than scheduled values.

D. Balancing:

1. Unless noted otherwise, each fan wheel shall be statically and dynamically balanced to ASA S2.19 Grade G6.3.
2. Fans controlled by variable frequency drives shall be dynamically balanced at speeds 25 percent, 50 percent, 75 percent, and 100 percent of design revolutions per minute.

E. Vibration Test:

1. Each fan furnished with 5-horsepower or larger motor shall have factory run vibration test, including vibration signatures taken on each bearing in horizontal, vertical, and axial direction.
2. Vibration reading as measured at scheduled rotational speed shall not exceed the following values when fan is rigidly mounted:
   a. Belt Drive (except Vane Axial): 0.15 inch per second peak velocity.
   b. Belt Drive Vane Axial: 0.08 inch per second peak velocity.
   c. Direct Drive: 0.08 inch per second peak velocity.
3. Written records of run test and vibration test shall be made available upon request.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install fans level and plumb.

B. Secure roof-mounted fans to roof curbs with **[A: cadmium-plated steel] [B: Type 316 stainless steel]** hardware.

C. Ceiling Units: Suspend units from structure; use steel wire or metal straps.

D. Scroll Drains: Pipe drain connection through running trap to floor drain.

E. Labeling:

1. Label fans in accordance with Article Accessories.
2. Mark exhaust fans serving fume hoods with arrows to indicate proper direction of rotation, in accordance with NFPA 45.

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F. Service Access: Locate units to provide access spaces required for motor, drive, bearing servicing, and fan shaft removal.

G. Equipment Support and Restraints:

1. Refer to Section 23 05 48, Vibration Isolation **[A: and Seismic Control]**.
2. Install floor-mounted units on concrete bases **[B: designed to withstand, without damage to equipment, the seismic force required by code]**.
3. Secure vibration **[C: and seismic]** controls to concrete bases using anchor bolts cast in concrete base.
4. Seismic Restraint Snubbers: Install with sufficient clearance so unit isolators are not restricted for proper free isolation, but do limit movement in all directions.

H. Connections:

1. Refer to Section **[A: 23 31 13, Metal Ducts and Accessories] [B: and] [C: 23 31 16.16, Thermoset Fiberglass-Reinforced Plastic Ducts and Accessories]**.
2. Isolate duct connections to fans.
3. Install ductwork adjacent to fans to allow proper service and maintenance.

3.02 FIELD QUALITY CONTROL

A. Functional Tests:

1. Verify blocking and bracing used during shipping are removed.
2. Verify fan is secure on mountings and supporting devices, and connections to ducts and electrical components are complete.
3. Verify proper thermal-overload protection is installed in motors, starters, and disconnect switches.
4. Verify cleaning and adjusting are complete.
5. Disconnect fan drive from motor; verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation.
6. Reconnect fan drive system; align and adjust belts and install belt guards.
7. Verify lubrication for bearings and other moving parts.
8. Verify manual and automatic volume control and fire and smoke dampers in connected ductwork are in fully open position.

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B. Performance Tests:

1. Starting Procedures:
   a. Energize motor and adjust fan to indicated revolutions per minute.
   b. Measure and record motor voltage and amperage.
2. Operational Test:
   a. After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   b. Repair or replace malfunctioning units; retest as specified after repairs or replacement is made.
   c. Test and adjust control safeties.
   d. Replace damaged and malfunctioning controls and equipment.

3.03 MANUFACTURER'S SERVICES

A. Manufacturer's Representative: Present at site or classroom designated by **[A: Owner,] [B: ,]** for minimum person-days listed below, travel time excluded:

1. **[C:]** person-days for **[D: installation assistance] [E: and] [F: inspection.]**
2. **[G:]** person-days for **[H: functional] [I: and] [J: performance]** testing and completion of Manufacturer's Certificate of Proper Installation.
3. **[K:]** person-days for prestartup classroom or site training.
4. **[L:]** person-days for facility startup.
5. **[M:]** person-days for post-startup training **[N: of Owner's personnel.]**
6. **[O: Training shall not commence until an accepted detailed lesson plan for each training activity has been reviewed by [P: Owner] [Q: Engineer] [R:].]**

B. Refer **[A: Section 01 43 33, Manufacturers' Field Services] [B: and] [C: Section 01 91 14, Equipment Testing and Facility Startup.]**

3.04 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust belt tension.

C. Lubricate bearings.

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D. Balancing:

1. Perform air system balancing as specified in Section 23 05 93, Testing, Adjusting, and Balancing for HVAC.
2. Replace fan and motor sheaves as required to achieve design airflow.

E. Vibration Testing:

1. Perform field testing on rotating equipment, where specified in Section 23 05 93, Testing, Adjusting, and Balancing for HVAC, to determine actual operating vibration.
2. If vibration limits described therein are exceeded, rebalance equipment in-place until design tolerances are met.
    a. Vibration readings as measured at actual rotational speed shall not exceed the following values:
        1) Belt Drive, Flexibility Mounted: 0.25 inch per second peak velocity.
        2) Belt Drive, Rigidly Mounted: 0.16 inch per second peak velocity.

3.05 CLEANING

A. After completing system installation, including outlet fitting and devices, inspect exposed finish. Remove burrs, dirt, and construction debris, and repair damaged finishes.

B. On completion of installation, internally clean fans according to manufacturers' written instructions. Remove foreign material and construction debris. Vacuum fan wheel and cabinet.

END OF SECTION

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SECTION 23 36 00
AIR TERMINAL UNITS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Air Movement and Control Association (AMCA): 300, Reverberant Room Method for Sound Testing of Fans.
2. ASTM International (ASTM): E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
3. Institute of Electrical and Electronics Engineers, Inc. (IEEE): 112, Standard Test Procedure for Polyphase Induction Motors and Generators.
4. National Electrical Manufacturers Association (NEMA): MG 1, Motors and Generators.
5. National Fire Protection Association (NFPA):
   a. 70, National Electric Code (NEC).
   b. 90A, Standard for the Installation of Air-Conditioning and Ventilating Systems.
   c. 255 Standard Method of Test of Surface Burning Characteristics of Building Materials.
6. UL: Product Directories.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Anchorage and bracing drawings and data sheets, as required by Section 01 88 15, Anchorage and Bracing.
2. Manufacturer’s product information including complete specifications, descriptive drawings, catalog cuts, and descriptive literature which shall include make, model, dimensions, weight of equipment, electrical schematics, and noise and pressure loss data.
3. Complete fan performance data.

B. Informational Submittals:

1. Recommended procedures for protection and handling of equipment and materials prior to installation.
2. Manufacturer’s Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements.

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3. For motors specified to be energy efficient type, certified copy of test report for identical motor tested in accordance with NEMA MG 1-12.53a and IEEE 112, Test Method B, showing full load efficiency meeting or exceeding specified values.
4. Detailed information on structural, mechanical, electrical, or other modifications necessary to adapt the arrangement or details shown to the products furnished.
5. Operation and Maintenance Data: As specified in Section 01 78 23, Operation and Maintenance Data. Include as-built version of equipment schedules.

PART 2 PRODUCTS

2.01 GENERAL

A. Specified components of this section, including insulation, facings, mastics and adhesives, shall have fire hazard rating not to exceed 25 for flame spread without evidence of continued progressive combustion, and 50 for smoke developed, as per test conducted in accordance with ASTM E84 and NFPA 255 methods.

2.02 EQUIPMENT SCHEDULES

A. For equipment capacities and individual unit features see equipment schedules.

B. Refer to Drawings.

2.03 VARIABLE AIR VOLUME UNITS

A. Construction:

1. Single duct terminal control unit with pressure independent automatic damper operation.
2. Cabinet Materials: 22-gauge, zinc-coated steel with factory applied enamel paint finish, or galvanized sheet steel.
3. Insulate internal surfaces acoustically and thermally with 1/2-inch-thick, 2-pound density, matte-faced insulation.
4. Automatic Dampers: Factory install and test.

B. Controls:

1. Adjustable for a maximum reduction of air volume to 20 percent of the design air volume.
2. Factory install damper operators furnished under Section 23 09 00, Instrumentation and Control Devices for HVAC.

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3. Capable of modulating, in sequence, the damper in response to the space thermostat.

C. Manufacturers and Products:

1. Trane; Model VC.
2. Carnes; Model AV.
3. Titus; Model ESV.

2.04 ACCESSORIES

A. Equipment Identification Plates: Furnish 16-gauge Type 316 stainless steel identification plate securely mounted on each separate equipment component and control panel in a readily visible location. Plate shall bear 3/8 -inch-high engraved block type black enamel filled equipment identification number and letters indicated in this specification and as shown.

B. Lifting Lugs: Furnish suitably attached for equipment assemblies and components weighing over 100 pounds.

2.05 SOURCE QUALITY CONTROL

A. Factory Tests: Leak test heating coils underwater with 250 psig air; no leaks allowed.

PART 3 EXECUTION

3.01 INSTALLATION

A. Support terminal control units from structure with galvanized steel straps or threaded rods from four corners of the unit.

B. Provide four duct diameters of straight duct length to the air terminal unit inlet to allow for proper control, unless otherwise allowed by the unit manufacturer.

C. Duct Connections: As specified in Section 23 31 13, Metal Ducts and Accessories.

D. Wiring Connections: As specified in Section 23 09 00, Instrumentation and Control Devices for HVAC.

END OF SECTION

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SECTION 23 37 00
AIR OUTLETS AND INLETS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Air-Conditioning, Heating, and Refrigeration Institute (AHRI): 880, Air Terminals.
2. ASTM International (ASTM): C636/C636M, Standard Practice for Installation of Metal Ceiling Suspension Systems for Acoustical Tile and Lay-in Panels.
3. Underwriters Laboratories Inc. (UL).

1.02 DEFINITIONS

A. NC: Noise Criteria; background sound rating method for indoor sound.

B. VAV: Variable air volume.

C. WC: Water column.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Manufacturer’s data and descriptive literature for products specified.
   b. Furnish the following information for each type of diffuser, register, and grille furnished.
      1) NC sound data.
      2) Static pressure loss data.
      3) Throw data.

PART 2 PRODUCTS

2.01 EQUIPMENT SCHEDULES

A. Refer to Drawings.

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2.02 CEILING DIFFUSERS

A. Louvered Face Diffusers (CD2):

1. Construction: As follows.
    a. Material: welded aluminum.
    b. Finish: Baked white enamel face finish. Flat black interior.
    c. Neck: Round.
2. Removable core section of louvers.
3. Continuous sponge rubber gasket at face flange.
4. Performance: Refer to Equipment Schedule.
    a. Distribution Pattern: 4-way. As shown on Drawings.
5. Manufacturers and Products:
    a. Krueger; Model 51400 (aluminum).
    b. Carnes; Type: Type SFAB (aluminum).
    c. Titus; type TMS-AA (Aluminum).

B. Adjustable Round Face Diffusers (CD6):

1. Construction: As follows.
    a. Material: Welded aluminum.
    b. Finish: Baked white enamel face finish. Flat black interior.
    c. Neck: Round.
2. 360-degree discharge pattern.
3. Fully adjustable throw from horizontal to vertical, from face of diffuser, by rotation of center cone.
4. Three removable center cones for duct maintenance access.
5. Continuous sponge rubber gasket at face flange.
6. Performance: Refer to Equipment Schedule.
7. Manufacturers and Products:
    a. Krueger; Model RA2 (steel).
    b. Carnes; Type SSAA (steel).
    c. Titus; Model TMRA-AA (aluminum).

2.03 SUPPLY GRILLES AND REGISTERS

A. Supply Grilles and Registers (SG1, SR1):

1. Construction: As follows.
    a. Material: Aluminum.
    b. Finish: Baked white enamel face finish.
2. Adjustable front horizontal and rear vertical vanes on 3/4-inch centers.
3. Continuous sponge rubber gasket at face flange.
4. 1-inch minimum flat rectangular frame.
5. Performance: Refer to Equipment Schedule.

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6. Manufacturers and Products:
    a. Krueger; 880/5880 Series.
    b. Titus; Airblade 272 Series.

2.04 RETURN, EXHAUST AND TRANSFER GRILLES AND REGISTERS

A. Louvered Return, Exhaust and Transfer Grilles and Registers (RG1, RR1, EG1, ER1, TG1):

1. Construction: As follows.
    a. Material: Aluminum.
    b. Finish: Baked white enamel face finish.
2. Fixed horizontal louvers set at 35 degrees to 45 degrees.
3. 1-inch minimum flat, rectangular frame.
4. Manufacturers and Products:
    a. Krueger; S80/S580H Series.
    b. Carnes; Type RAAAH.
    c. Titus; 350 RL Series.

PART 3 EXECUTION

3.01 INSTALLATION

A. Refer to architectural reflected ceiling plans for coordination of locations of ceiling-mounted air outlets and inlets with ceiling grids and lighting. Where locations of devices shown on mechanical drawings do not agree with locations that are shown on architectural reflected ceiling plans, reflected ceiling plans shall take precedence. If air outlets or inlets are shown on mechanical drawings, but are not shown on architectural reflected ceiling plans, devices shall be located as near as possible to locations shown on mechanical drawings when coordinating with ceiling.

B. Install diffusers, grilles, and registers tight on their respective mounting surfaces, level, plumb, and true with room dimensions.

C. Provide appropriate frame to adapt to mounting surface. Provide a 24-inch by 24-inch lay-in ceiling module for diffusers, registers, and grilles in lay-in ceilings.

D. Support air inlets and outlets where installed in metal suspension systems for acoustical tile and lay-in panel ceilings as specified in ASTM C636/C636M.

END OF SECTION

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SECTION 23 77 00
AIR HANDLING UNITS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Air-Conditioning, Heating, and Refrigeration Institute (AHRI): 410, Forced-Circulation Air-Cooling and Air-Heating Coils.
2. Air Movement and Control Association International, Inc. (AMCA):
   a. 201, Fans and Systems.
   b. 203, Field Performance Measurement of Fan Systems.
   c. 204, Balance Quality and Vibration Levels for Fans.
   d. 300, Reverberant Room Method for Sound Testing of Fans.
   e. 301, Methods for Calculating Fan Sound Ratings From Laboratory Test Data.
   f. 99-0401, Classifications for Spark Resistant Construction.
   g. 99-2408, Operating Limits for Centrifugal Fans.
3. American Bearing Manufacturers Association (ABMA): 9, Load Ratings and Fatigue Life for Ball Bearings.
4. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE):
   a. 15, Safety Standard for Refrigeration Systems.
   b. 52.1, Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter.
   c. 52.2, Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size.
   d. 62.1, Ventilation for Acceptable Indoor Air Quality.
5. ASTM International (ASTM):
   a. B117, Standard Practice for Operating Salt Spray (Fog) Apparatus.
   b. D2247, Standard Practice for Testing Water Resistance of Coatings in 100% Relative Humidity.
   c. D2794, Standard Test Method for Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact).
   d. D3363, Standard Test Method for Film Hardness by Pencil Test.
   e. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
6. CSA America (CSA):
   a. B149.1, Natural Gas and Propane Installation Code.
   b. Z83.4, Non-Recirculating Direct Gas-Fired Industrial Air Heaters.
   c. Z83.18, Recirculating Direct Gas-Fired Industrial Air Heaters.

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7. Institute of Electrical and Electronics Engineers, Inc. (IEEE): 841, Standard for Petroleum and Chemical Industry - Severe Duty Totally Enclosed Fan-Cooled (TEFC) Squirrel Cage Induction Motors - Up to and Including 370 kW (500 hp).
8. International Standards Organization (ISO): 9001, Quality Management Systems – Requirements.
9. National Electrical Manufacturers Association (NEMA).
10. National Fire Protection Association (NFPA):
    a. 54, National Fuel Gas Code.
    b. 90A, Standard for the Installation of Air-Conditioning and Ventilating Systems.
    c. 255, Standard Method of Test of Surface Burning Characteristics of Building Materials.
11. Occupational Safety and Health Act (OSHA).
12. Society of Protective Coatings (SSPC):
    a. SP 3, Power Tool Cleaning.
    b. SP 5, White Metal Blast Cleaning.
    c. SP 6, Commercial Blast Cleaning.
    d. SP 10, Near-White Blast Cleaning.
13. Underwriters Laboratories Inc. (UL):
    a. 181, Standard for Safety Factory-Made Air Ducts and Connectors.
    b. 723, Standard for Safety Test for Surface Burning Characteristics of Building Materials.

1.02 DEFINITIONS

A. The following is a list of abbreviations which may be used in this section:

1. ac: alternating current.
2. AFD: Adjustable Frequency Drive.
3. AHU: Air Handling Unit.
4. cfm: cubic feet per minute.
5. CISD: Chemical Industry, Severe-Duty.
6. dB: Decibel.
7. DX: Direct Expansion.
8. DWDI: Double Width, Double Inlet.
9. ETL: ETL Testing Laboratories, Inc.
10. FM: Factory Mutual Insurance.
11. fpm: feet per minute.
12. hp: Horsepower.
13. IAQ: Indoor Air Quality.
14. IEC: International Electro-technical Commission.
15. IRI: Industrial Risk Insurance.
16. MAU: Make-Up Air Unit.
17. NRC: Noise Reduction Coefficient.

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18. OD: Outside Diameter.
19. ODP: Open Drip Proof.
20. O&M: Operations and Maintenance.
21. psi: pounds per square inch.
22. PVC: Polyvinyl Chloride.
23. rpm: revolutions per minute.
24. SCR: Silicon Control Rectifier.
25. SWSI: Single Width, Single Inlet.
26. TEFC: Totally Enclosed, Fan Cooled.
27. UV: Ultra Violet.
28. VFD: Variable Frequency Drive.
29. WC: Water Column.
30. XP: Explosion Proof.

1.03 SUBMITTALS

A. Action Submittals:

1. Provide Shop Drawings for products specified, including, as a minimum:
    a. Unit identification as referenced in Contract Documents.
    b. Manufacturer's name and model number.
    c. Descriptive specifications, literature, and drawings.
    d. Dimensions and weights for unit, including fully assembled and shipping sections.
    e. Acoustics:
        1) Fan sound power level data (ref. 10 to power minus 12 Watts) at design operating point, based on AMCA 300 for unit discharge, inlet and casing.
        2) Additional requirements (including by others) to achieve specified sound performance levels.
    f. Fans:
        1) Type, size, quantity, class, drive arrangement, discharge, rotation and bearings.
        2) Wheel type, diameter, rpm, and tip speed.
        3) Performance curves indicating:
            a) Relationship of flow rate to static pressure for various fan speeds.
            b) Brake horsepower curves.
            c) Acceptable selection range (surge curves, maximum safe operating rpm).
            d) Static pressure, capacity, horsepower demand and overall efficiency required at the duty point, including drive losses.

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4) For variable air volume applications, indicate operating points at 100, 80, 60, and 40 percent of design capacity on fan curves including data to indicate effect of capacity control devices such as inlet vanes on flow, pressure and brake horsepower.

g. Coils:
   1) Type, quantity, dimensions, material of construction, coatings, if applicable, energy transfer capacity, air pressure drop, air inlet, and discharge temperature at design conditions.
   2) DX Coils: Refrigerant saturated suction temperature at design conditions, refrigerant piping configuration (row split, face split, intertwined), coil fin spacing, coil row depth.
   3) Evaporative Coolers: Media air pressure drop at design conditions, make-up water consumption, air discharge temperature and humidity at design conditions, piping connection data.
   4) Electric Resistance Coils: Voltage, phase, number of stages, safety features, controls.
   5) Drain pan details.
   6) Coil pull details and dimensions for service.

h. Motor(s) type, quantity, and performance data.

i. Air filter(s) type, quantity, and performance data.

j. Unit capacities and ratings, including airflow and static pressure summary.

k. Construction materials.

l. Power and control wiring diagrams, including terminals and numbers.

m. Vibration Isolation:
   1) Vibration isolation methods with maximum deflection data.
   2) Additional requirements (including by others) to achieve specified vibration isolation levels.

n. Factory finish system, with color selection charts where applicable.

o. Corrosion protection coating product data.

2. “Or Equal” Equipment:
   a. Where submitted equipment results in change to fan inlet or outlet ductwork configuration shown on drawings, submit system effect factor calculations indicating increased static pressure requirements as described in AMCA 201.

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b. Where submitted equipment results in change to ductwork and equipment configuration shown on drawings, submit detailed information on structural, mechanical, electrical, or other modifications necessary to adapt arrangement or details shown to equipment furnished.

B. Informational Submittals:

1. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements.
2. Sample copy of guarantee.
3. Manufacturer's Test Reports for the following:
   a. Electric heating coil.
   b. DX cooling coil.
4. Recommended procedures for protection and handling of products prior to installation.
5. Manufacturer's installation instructions, including component spacing requirements.
6. Operation and Maintenance Data:
   a. In conformance with Section 01 78 23, Operation and Maintenance Data.
   b. Include as-built version of equipment schedules.
   c. Methods for accessing components for maintenance with required service clearances.

1.04 QUALITY ASSURANCE

A. Fans: Licensed to bear AMCA seal for air flow and sound performance.

B. Manufacturer's Qualifications:

1. The air handling unit manufacturer shall have been successfully manufacturing air handling units for a period of no less than 5 years.
2. Manufacturer's qualifications are subject to review by the Owner/Engineer to determine acceptance.

C. Fan Performance:

1. Fan shall operate at single stable point as indicated by fan curve. Fans having two potential operating points are not acceptable.
2. Fan and motor combination shall be capable of delivering 110 percent of scheduled air quantity and static pressure.
3. Motor shall not operate into motor service factor in any listed case.
4. Accommodate drive efficiency in motor selection according to manufacturer's published recommendation, or according to AMCA 203, Appendix L.

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D. Thermal Insulation: Shall meet the erosion requirements of UL 181 facing the air stream and fire hazard classification of 25/50 (per ASTM E84 and UL 723).

1.05 DELIVERY, STORAGE, AND HANDLING

A. Air handling unit manufacturer shall coordinate with the Contractor as to the requirements for proper delivery, storage, and handling of the air handling unit and its components required in this Specification to ensure that the unit is properly cared for prior to final installation.

1.06 EXTRA MATERIALS

A. Furnish, tag, and box for shipment and storage the following **[A: spare parts,] [B: special tools,] [C: and] [D: materials:]**

Item	Quantity
Pre-filters	Four complete sets per unit
Special tools required to maintain or dismantle	One complete set for each different size unit

B. Delivery: In accordance with Section 01 61 00, Common Product Requirements.

PART 2 PRODUCTS

2.01 EQUIPMENT SCHEDULES

A. Refer to Drawings.

2.02 OPERATING LIMITS

A. Fans designated to meet a specified Fan Class shall comply with requirements of AMCA 99-2408.

2.03 ACOUSTICAL LEVELS

A. Equipment selections shall produce sound power levels in each octave band no greater than shown in fan equipment schedule.

B. Perform noise tests in accordance with AMCA 300.

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2.04 FAN DRIVES

A. Furnish multiple drive belts.

B. Drive assembly shall be sized for a minimum 150 percent of fan motor horsepower rating.

C. Motors for V-belt drives shall be furnished with adjustable rails or bases.

D. Unless otherwise noted, furnish belt-driven fans with cast iron or flanged steel fixed sheaves.

E. Motors: Fixed-pitch sheaves required.

F. Drive Adjustment:

1. When fixed-pitch sheaves are furnished, accomplish system air balancing by either trial of different fixed-pitch sheaves or use of temporary adjustable-pitch sheaves.
2. Provide trial and final sheaves, as well as drive belts, as required.

G. Weather Cover: For outdoor applications, factory fabricated drive assembly of same material as fan housing, unless specified otherwise.

H. Belt and Shaft Guards:

1. Easily removable and to enclose entire drive assembly, meeting federal, OSHA requirements.
2. Guard faces of expanded metal having minimum 60 percent free area for ventilation.
3. Bright yellow finish.

I. Provide speed test openings at shaft locations.

2.05 FINISHES

A. Carbon Steel Parts: Factory finished as follows, unless indicated otherwise.

1. Parts cleaned and chemically pretreated with a phosphatizing process.
2. Alkyd enamel primer.
3. Air-dry enamel topcoat.

B. Aluminum Parts: Finished smooth and left unpainted, unless stated otherwise.

C. Stainless Steel Parts: Finished smooth and left unpainted.

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2.06 AIR HANDLING UNITS—MODULAR

A. General:

1. Modular air handling unit, constructed by assembly of factory-fabricated modules containing components such as fan units, motor and drive assembly, heat transfer devices, dampers, plenums, filters, condensate pans, heating units, control devices, and accessories.
2. Required module types as indicated on plans and equipment schedule.
3. Assembly shall be a complete and fully functioning system with all components and accessories as specified.
4. Fan Air and Sound Performance: Tested and rated in accordance with AMCA and guaranteed by manufacturer.

B. Module Casing:

1. General:
   a. Each module fully enclosed housing, with casing consisting of sheet metal side, floor and roof panels, mechanically fastened to structural metal internal frame.
   b. Wall panels shall be easily removable. Panel removal shall not affect structural integrity of unit.
   c. Height and width dimensions identical for each module type, for a given unit size.
   d. Lifting lugs and unit support frames, factory installed, to facilitate installation.
   e. All casing insulated, formed and reinforced sheet metal panels; flat panel design not acceptable.
   f. For double wall units, distance between inner and outer panels as required to accommodate insulation thickness specified in Paragraph Insulation. Units are double wall, unless noted otherwise.
   g. Each panel shall be removable from outside of unit without affecting unit structural integrity.
2. Outdoor Units:
   a. Weathertight and rated for outdoor use.
   b. Cross broke/sloped roofcap system.
   c. Drip shield/overhang provided on all four sides of unit.
   d. Caulked/sealed standing top seams to assure waterproofing.
3. Fasteners: Constructed of same material as respective module panel materials.

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4. Outer Panels:
    a. Material: G-90 galvanized steel with corrosive resistance.
    b. Indoor Units:
        1) Walls: Minimum 16-gauge (0.0625 in.) thickness sheet metal.
        2) Roof: Minimum 16-gauge (0.0625 in) thickness sheet metal.
    c. Outdoor Units:
        1) Walls: Minimum 14-gauge (0.0800 in.) thickness sheet metal.
        2) Roof: Minimum 14-gauge (0.0800 in.) thickness sheet metal.
5. Inner Panels:
    a. Walls and Roof:
        1) Material: G-90 galvanized steel with corrosive resistance.
        2) Minimum 20-gauge (0.0348 in.) thickness sheet metal, perforated.
    b. Floor Plate:
        1) Material: G-90 galvanized steel with corrosive resistance.
        2) Minimum 14-gauge (0.0800 in.) thickness sheet metal.
6. Frame:
    a. Material: G-90 galvanized steel with corrosive resistance.
    b. Fabricated from minimum 16-gauge metal sections.
    c. Metal sections joined to form a unitized assembly, for support of module internal components.
7. Joints:
    a. Joints between exterior panels and structural frames shall have seals and gaskets with appropriate material type for air seal and acoustical break.
    b. All seams caulked and sealed for an airtight unit.
    c. Fully through-bolted module to module joints sealed with bulb type gasketing on both mating modules.
8. Insulation:
    a. Double Wall Casing Units: Insulation fully encased between outside and inside panels. Units are double wall, unless noted otherwise.
    b. Properties:
        1) 1-inch thickness, 3 pounds per cubic foot density.
        2) Units with Perforated Liner:
            a) Black composite protective coating on surface exposed to airstream.
            b) Exposed insulation is not acceptable.
        3) Maximum effective thermal conductivity (C) of 0.24 Btu inch per square foot degrees F.
        4) Minimum NRC of 0.70 per inch thickness.
    c. Manufacturer: Johns Manville.

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9. Access Doors:
    a. Heavy-gauge, oversized access doors insulated, double wall construction, internal sheet metal skin.
    b. Sized and located to provide easy access to unit internal components.
    c. Hinged, latched, and gasketed to provide a weatherproof seal.
    d. Provide doors on one side of each module.
    e. Latches:
        1) "Ventlok" style noncorrosive alloy latches operable from inside and outside of unit.
        2) For access doors configured to open against unit operating pressure, provide safety latches that allow access doors to partially open after first handle movement and fully open after second handle movement.
10. Air Leakage: Maximum of 0.5 cfm per square foot of cabinet area at 5-inch WC static pressure.

C. Module Drain Pans:

1. Location: Inside each module, under each cooling coil and where indicated in these Specifications.
2. IAQ style drain pans, complying with requirements of ASHRAE 62.1.
3. Formed sections of minimum 16-gauge (0.0625 in.) Type 316 stainless steel.
4. Triple pitched for complete drainage, with no standing water in unit.
5. Double Wall Construction:
    a. Space between walls filled with foam insulation.
    b. Sealed moisture tight.
    c. Welded corners.
6. Drain Connections:
    a. Type 304 stainless steel, male pipe thread.
    b. Both ends of pan.
    c. Extended to exterior of unit cabinet.
    d. Connection centerline shall be a minimum of 3 inches above base rail. Drain connections that protrude from the base rail are not acceptable.

D. Unit Base:

1. Full perimeter base frame.
2. Minimum 10-gauge (0.135 in.) structural steel construction, with C channel cross support members, on close centers.
3. Joints fully welded.
4. Fitted with lifting lugs at corner of unit or module.
5. Attached to unit at factory unless noted otherwise for field assembly.

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E. Supply Fan Module:

1. General:
    a. Supply air module with fan assembly, consisting of housing (where applicable), wheel, fan shaft, bearings, motor, lockable disconnect switch, drive assembly, support structure and accessories.
    b. Casing constructed in accordance with Article Module Casing.
    c. Suitable to convey air at temperatures up to 250 degrees F.
    d. Fan Performance: AMCA 99-2408 class rating corresponding to the static pressure at which the fan is designed to operate.
    e. Fan Assemblies: Statically and dynamically balanced, designed for continuous operation at maximum rated fan speed and motor horsepower.
2. Centrifugal Fan Housing:
    a. Material: Aluminum.
    b. Construction:
        1) Formed and reinforced sheet metal panels, curved scroll configuration with shaped cutoff, continuous seam welding and side angle reinforcement.
        2) Flanged and drilled outlet to permit duct connection.
        3) Spun-formed aerodynamic bell mouth inlet.
        4) Access doors or panels to allow entry to internal parts and components.
        5) Base:
            a) All-welded heavy-gauge metal.
            b) Fan and motor mounted on common base.
            c) Motor Mount: Adjustable slide mount.
    c. Plug Fans: Fabricate without fan scroll and volute housing.
    d. Hardware: Plated steel.
3. Fan Wheel:
    a. Centrifugal, one-piece, blade type as scheduled.
    b. Forward-Curved Fans:
        1) DWDI forward curved fan wheel.
        2) Shallow blades with inlet and tip curved forward in direction of airflow, metal construction, mechanically secured to backplate and inlet flange.
    c. Backward Inclined Fans:
        1) DWDI backward inclined fan wheel.
        2) Nonoverloading performance characteristics.
        3) Backward inclined blades, heavy-gauge metal construction, continuously welded to backplate and curved inlet flange.
    d. Airfoil Fans:
        1) DWDI backward inclined fan wheel.
        2) Nonoverloading performance characteristics.

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3) Backward inclined blades, hollow die-formed airfoil design, heavy gauge metal construction, continuously welded to backplate and smooth curved inlet flange.

e. Plenum Fans:
1) SWSI backward inclined fan wheel.
2) Nonoverloading performance characteristics.
3) Backward inclined blades, hollow die-formed airfoil design, heavy-gauge metal construction, continuously welded to backplate and smooth curved inlet flange.

f. Material: Carbon steel.

g. Attached to fan shaft with split taper lock bushing.

4. Fan Shaft, Bearings, Drive:
a. Shafts:
1) Turned, ground, and polished carbon steel.
2) Ends drilled and countersunk for tachometer readings.
3) Keyed for sheave installation.
4) Coated with lubricating oil.

b. Bearings:
1) Grease lubricated, precision anti-friction ball, self-aligning type.
2) Mounted in cast iron pillow block housing.
3) Selected for average life (ABMA 9 L_{50}) of not less than 200,000 hours operation at maximum cataloged operating speed.

c. Drives:
1) In accordance with Article Fan Drives.
2) Factory set to specified fan revolutions per minute.
3) Type: Belt or Direct.
4) Arrangement: As specified and as shown on Drawings.

5. Internal Vibration Isolation:
a. Fan/Motor Base: Isolate base from unit casing with open spring isolators with 2-inch deflection.

b. Flexible Connectors: Install flexible rubber seal between fan and unit casing to ensure complete isolation.

6. Accessories:
a. Fan Drive Belt Guard:
1) Unit shall be provided with an OSHA-approved galvanized, expanded-metal belt guard that totally encloses the drive.
2) Belt guard shall be rigidly attached to the bearing support structure and have a removable front panel.
3) A tachometer hole shall be provided opposite the fan shaft.
4) Guard shall be of a universal size to accommodate any applicable drive configuration.

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F. Refrigerant Coil Module:

1. General:
    a. Fin-tube direct expansion refrigerant cooling coil, complete with refrigerant controls, and related accessories.
    b. Casing constructed in accordance with Article Module Casing.
    c. AHRI 410 performance rated and certified.
    d. Factory tested with air at 300 psig while immersed in an illuminated water tank.
    e. Designed and tested in accordance with ASHRAE 15.
    f. Coil shipped with end connections sealed and filled with a charge of dry nitrogen.
    g. Coils designed for use with refrigerant type in associated refrigerant compressor.
2. Pipe Chase:
    a. All piping and piping mounted controls located in pipe chase.
    b. Chase construction and insulation as for unit modules.
    c. Internal or External to module casing.
    d. Adequately sized access door(s) for installation and maintenance of all piping.
3. Coil Assembly:
    a. Refrigerant Piping Connections:
        1) On same side of module.
        2) Extended a minimum of 5 inches beyond the exterior of the unit casing, by the manufacturer.
    b. Coils removable from the unit at header end, unless shown otherwise on Drawings.
    c. Clearly label liquid and suction headers on outside of module.
4. Refrigerant Circuiting:
    a. Row split intertwined, multiple distributor arrangement.
    b. Alternate tube circuited in order to distribute the cooling effect over the entire coil face at reduced load conditions.
    c. Refrigerant Distributors: Brass, replaceable nozzle type, connected to the coil by copper tubes.
5. Fins:
    a. Die-formed plate type, rippled for maximum heat transfer.
    b. Continuous metal across coil casing; split fins not acceptable.
    c. Shall have fully drawn collars and be mechanically bonded to tubes by mechanical expansion of tubes.
    d. Material: 0.0095 -inch aluminum.
    e. Fin density no greater than 12 fins per inch.
6. Tubes:
    a. Material: 1/2 inch-OD by 0.025-inch wall seamless copper tubing.
    b. Return Bends: Replaceable, brazed joints, 0.049 -inch wall thickness.

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c. Intermediate tube supports shall be supplied on coils over 44-inch fin length with an additional support every 42-inch multiple thereafter.

7. Headers:
   a. Located inside module.
   b. Constructed from seamless copper tubing with die formed tube holes and brazed joints.
   c. Refrigerant Piping Connections: Terminate with OD sweat copper.
8. Casings:
   a. Construct from minimum 16-gauge (0.0625 in.) G-90 galvanized steel with corrosive resistance.
   b. Formed end supports and top and bottom channels.
9. Drain Pan:
   a. Construction in accordance with Paragraph, Module Drain Pans.
   b. Furnish drain pan under each cooling coil.
10. Accessories:
    a. Coil Protective Coating:
       1) Provide factory applied corrosion protection coating on these coil components:
          a) Coil assembly, including exterior surfaces of fins and tubes.
          b) Refrigerant piping, headers, distributors, exposed to the air stream.
          c) Coil casings.
       2) Coating system type shall be factory dip-applied, in accordance with Article Coil Protective Coating.

G. Electric Heating Coil Module:

1. General:
   a. Electric blast-type coil process heater, of low-watt density design.
   b. Casing constructed in accordance with Article Module Casing.
   c. Air pressure drop through heaters 0.25-inch WC maximum.
   d. Electric heaters shall be UL or ETL listed for zero clearance and 100,000 cycles of operation, and shall meet all applicable NEC requirements.
   e. UL listed for 100,000 cycles of operation.
   f. Elements supported in aluminized steel frame.
   g. Element assembly furnished with mounting flanges, allowing individual element removal from terminal box.
   h. Stainless steel terminal bolts, nuts, and washers.
   i. Heaters with more than one stage shall have each stage cover the full face area of heater.

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2. Construction:
    a. Coil Type: Finned tubular.
    b. Finned Tubular:
        1) Finned tubular configuration.
        2) Resistance Wire Material: 80 percent nickel/20 percent chromium, Type A.
        3) Type 304 stainless steel fins, helically wound onto tube.
        4) Tube filled with granular magnesium oxide, with resistance wire precisely centered.
        5) Silicon rubber end seals.
3. Electrical/Controls:
    a. Magnetic Contactors: Built-in, with 120-volt holding coils.
    b. Wiring:
        1) Stranded copper, 105 degrees F insulation, terminated with crimped connectors or boxed lugs.
        2) Terminals:
            a) Line and control wiring factory prewired to terminal strips for line and control connections.
            b) Clearly labeled.
    c. Fusing: Integral fuse blocks with fusing in each leg of each circuit for heater drawing more than 48 amps.
    d. Heat Stage Control: SCR type.
    e. Safeties:
        1) Over-temperature protection.
        2) Integral differential pressure type airflow safety switch.
        3) Manual reset thermal cutouts, wired to directly de-energize heater load.
        4) Automatic reset thermal cutouts, wired into control circuit.
        5) Over current protection, where required by UL or NEC.
    f. Panelboard: All electrical/control components housed in Panelboard, NEMA Type 3R enclosure.
4. Manufacturers:
    a. Indeeco.
    b. Brasch.

H. Access Module:

1. Access module to allow improved access to air handling internal components.
2. Casing constructed in accordance with Article Module Casing.
3. Double wall, hinged, removable access doors on one side of module.
4. Minimum depth of 16 inches, larger where shown on Drawings.

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I. Filter Module:

1. General:
   a. Air filtration module, complete with filter media and filter racks.
   b. Casing constructed in accordance with Article Module Casing.
   c. Double wall, hinged, removable access doors on both sides of module.
   d. Maximum 500 fpm face velocity across filters.
2. Media Schedule:
   a. Pre Filter: Angled V-bank arrangement.
3. Media Construction:
   a. General:
      1) Contain in a rigid frame.
      2) Meet UL Class 2 standards.
      3) Rigid supporting mesh across the leaving face of media.
      4) Quality certified by ISO 9001.
   b. Disposable Pleated Type:
      1) Pleated panel disposable filters.
      2) Nonwoven reinforced cotton/poly fabric media with a metal support grid and heavy duty beverage board-enclosing frame.
      3) 2-inch thickness.
      4) MERV 8 efficiency per ASHRAE 52.2.
      5) Minimum 30 percent dust spot efficiency and 90 percent average arrestance in accordance with ASHRAE 52.1.
4. Frame and Filter Assembly:
   a. Suitable for space indicated.
   b. Permanent re-usable, side-loading aluminum holding frame, retainer, and sealer frame.
   c. Filter blank-offs to prevent air bypass around filters, same material as frame.
5. Manufacturers:
   a. Farr.
   b. Flanders.
   c. Tri-Dim.
   d. American Air Filter.

J. Mixing Module:

1. General: Mixing and control of up to 80 percent return air and 20 percent outside air streams.
2. Include control dampers on return, exhaust, and outside air inlets.
3. Position dampers blades across short dimension of each air opening.
4. Linkages arranged so corresponding outside and return air dampers move together.

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5. Install damper linkage at factory to provide minimum and maximum damper segments proportional to required quantities of minimum and maximum outside air.
6. Damper Construction: In accordance with Article Control Dampers.

K. Outside Air Intake Module:

1. Weather Hood: Fully welded construction, fabricated from same material as unit casing.
2. Louver: Drainable type, S-shaped rainproof blades, spaced 2 inches maximum.
3. 1/2-inch mesh 316 Stainless Steel bird screen on inside face of louver.

L. Control Dampers:

1. Internally mounted ultra low leak dampers.
2. Parallel blade action for two-position applications and opposed blade action for modulating applications.
3. Construction:
   a. Extruded aluminum blades.
   b. Galvanized steel frame, U-shaped galvanized metal sections securely screwed or welded to unit chassis.
   c. Vinyl blade seals, stainless steel jam seals.
   d. Type 304 stainless steel linkage, shafts, and hardware.
   e. Type 304 stainless steel sleeve bearings.
4. Performance: Leakage rate shall not exceed 5 cfm per square foot at 1-inch WC and 9 cfm per square foot at 4-inch WC.

M. Unit Electrical and Controls:

1. General:
   a. Electrical and control components shall meet requirements of Division 26 Electrical.
   b. All electrical and controls components and assemblies UL or ETL listed and labeled.
   c. Factory wired units shall bear an ETL or UL label with all necessary identification marks, electrical data, and cautions, as required by NEC.
   d. Provide as-built wiring diagrams and schematics for electrical and control systems, secured to inside of control panel door, or enclosed in plastic jackets placed inside control panel.
   e. For additional requirements, refer to Specification paragraphs for individual modules, and Section 23 09 00, Instrumentation and Control Devices for HVAC.
2. Main Power Connection: Provide single point power connection to unit, serving both primary unit voltage and unit control voltage.

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3. Main Control Panel:
    a. Provide unit main control panel, with all electrical and control components housed in a single enclosure.
    b. NEMA Type 3R enclosure.
    c. Factory-mounted on exterior of unit casing, located on unit side.
    d. Same material/finish as unit casing.
    e. Adequate spare space for field installation of additional electrical and control components.
    f. Access Doors: Hinged, latched, and gasketed to provide a weatherproof seal.
4. Factory Installed Adjustable Frequency Drives:
    a. Provide for each motor indicated to be controlled by AFD.
    b. Factory installed in unit Main Control Panel.
    c. Factory wired to motor terminal box.
    d. NEMA Type 3R enclosure.
    e. Comply with requirements of Section 23 05 14, HVAC Adjustable Frequency Drives.]
5. Factory Installed Disconnects:
    a. Provide main electric power disconnect for unit.
    b. Provide electric power lockable disconnect for each module containing electrical components.
    c. NEMA Type 3R enclosure.
    d. Nonfused type.
    e. Factory installed on outside of fan module cabinet, and factory wired to electrical component terminals.]
6. Electrical Convenience Outlets:
    a. Duplex type, 120V, factory installed and wired.
    b. Location:
        1) On exterior of unit, next to each fan section access door.
        2) Inside unit Main Control Panel.
7. Control Damper Actuators:
    a. To suit factory installed control dampers.
    b. Type: Electric, 120V, factory installed, and wired to junction box.
    c. Manufacturer: Belimo.
8. Factory Installed Control System.

N. Manufacturers and Products:

1. Daikin McQuay; Vision (Indoor), Skyline (Outdoor).
2. Trane; Climate Changer, Series M (Indoor), Series T (Outdoor).
3. Carrier; 39MN (Indoor), 39MW (Outdoor).
4. Temtrol; ITF.
5. York.
6. Aaon.

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2.07 MAKE-UP AIR UNITS—INDUSTRIAL

A. General:

1. Custom air handling unit, constructed by assembly of factory-fabricated components such as fan units, motor and drive assembly, heat transfer devices, dampers, plenums, filters, condensate pans, heating units, control devices and accessories.
2. Required unit components as indicated on plans and equipment schedule.
3. Assembly shall be a complete and fully functioning system with all components and accessories as specified.
4. Fan Air and Sound Performance: Tested and rated in accordance with AMCA and guaranteed by manufacturer.

B. Unit Casing:

1. General:
   a. Fully enclosed housing, with casing consisting of sheet metal side, floor and roof panels.
   b. Lifting lugs and unit support frames, factory installed, to facilitate installation.
   c. All casing to consist of formed and reinforced sheet metal panels, insulated as indicated; flat panel design not acceptable.
   d. For double wall units, distance between inner and outer panels as required to accommodate insulation thickness specified in Paragraph, Insulation. Double wall units are required, unless noted otherwise.
2. Panel Arrangement: Panels mechanically fastened to a fully welded unitized frame assembly.
3. Outdoor Units:
   a. Weathertight and rated for outdoor use.
   b. Cross broken and sloped roofcap system.
   c. Drip shield/overhang provided on all four sides of unit.
   d. Caulked/sealed standing top seams to assure waterproofing.
4. Material: Panels, fasteners and structural metal frame members constructed from G-90 galvanized steel with corrosive resistance.
5. Outer Panels:
   a. Outdoor Units:
      1) Walls: Minimum 16-gauge (0.0625 in.) thickness sheet metal.
      2) Roof: Minimum 16-gauge (0.0625 in.) thickness sheet metal.

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6. Inner Panels:
    a. Walls and Roof: Minimum 20-gauge (0.0348 in.) sheet metal.
    b. Floor Plate: Minimum 16-gauge (0.0625 in.) thickness sheet metal.
7. Joints:
    a. Joints between exterior panels and structural frames shall have seals and gaskets with appropriate material type for air seal and acoustical break.
    b. Seams caulked and sealed for an airtight unit.
    c. Fully through-bolted section to section joints.
8. Insulation:
    a. Double Wall Casing Units: Insulation fully encased between outside and inside panels.
    b. Properties:
        1) 1-inch thickness, 3 pounds per cubic foot density.
        2) Units with Perforated Liner or Exposed Insulation: Black composite protective coating on surface exposed to airstream.
        3) Maximum effective thermal conductivity (C) of 0.24 Btu inch per square foot degrees F.
        4) Minimum NRC of 0.70 per inch thickness.
    c. Casing with perforated metal liner furnished with BGF 7628/252L fiberglass cloth used to prohibit the erosion of the insulation into the air stream.
    d. Manufacturer: Johns Manville.
9. Access Doors:
    a. Heavy-gauge, 0.0625 inch minimum, oversized access doors insulated, double wall construction, internal sheet metal skin.
    b. Sized and located to provide easy access to unit internal components.
    c. Hinged, latched, and gasketed to provide a weatherproof seal.
    d. Provide doors on one side(s) of each unit.
    e. Latches:
        1) “Ventlok” style noncorrosive alloy latches operable from inside and outside of unit.
        2) For access doors configured to open against unit operating pressure, provide safety latches that allow access doors to partially open after first handle movement and fully open after second handle movement.
10. Casing Performance:
    a. Air Leakage: Maximum of 0.5 cfm per square foot of cabinet area at 5-inch WC static pressure.
    b. Panel Deflection: For modules under negative pressure located on the suction side of the fan, maximum permissible panel deflection

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shall not exceed 1/200th of panel length, when subject to 8-inch WC differential pressure.

C. Drain Pans:

1. Location: Under each cooling coil, and where indicated in these Specifications.
2. IAQ style drain pans, complying with requirements of ASHRAE 62.1.
3. Formed sections of minimum 16-gauge (0.0625 in.) Type 316 stainless steel.
4. Triple pitched for complete drainage, with no standing water in unit.
5. Double Wall Construction:
    a. Space between walls filled with foam insulation.
    b. Sealed moisture tight.
    c. Welded corners.
6. Drain Connections:
    a. Type 304 stainless steel, male pipe thread.
    b. Both ends of pan.
    c. Extended to exterior of unit cabinet.
    d. Connection centerline shall be a minimum of 3 inches above base rail. Drain connections that protrude from the base rail are not acceptable.

D. Unit Base:

1. Full perimeter base frame.
2. Minimum 10-gauge (0.135 in.) structural steel construction, with C channel cross support members, on close centers.
3. All joints fully welded.
4. Fitted with lifting lugs at corner of unit.
5. Attached to unit at factory, unless noted otherwise for field assembly.

E. Supply Fan Section:

1. General:
    a. Supply air section with fan assembly, consisting of housing (where applicable), wheel, fan shaft, bearings, motor, disconnect switch, drive assembly, support structure, and accessories.
    b. Casing constructed in accordance with Article Unit Casing.
    c. Suitable to convey air at temperatures up to 250 degrees F.
    d. Fan Performance: AMCA 99-2408 class rating corresponding to the static pressure at which the fan is designed to operate.
    e. Fan Assemblies: Statically and dynamically balanced, designed for continuous operation at maximum rated fan speed and motor horsepower.

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2. Centrifugal Fan Housing:
    a. Material: G-90 galvanized steel with corrosive resistance.
    b. Construction:
        1) Formed and reinforced sheet metal panels, curved scroll configuration with shaped cutoff, continuous seam welding and side angle reinforcement.
        2) Flanged and drilled outlet to permit duct connection.
        3) Spun-formed aerodynamic bell mouth inlet.
        4) Access doors or panels to allow entry to internal parts and components.
        5) Base:
            a) All-welded heavy-gauge metal.
            b) Fan and motor mounted on common base.
            c) Motor Mount: Adjustable slide mount.
    c. Plug Fans: Fabricate without fan scroll and volute housing.
    d. Hardware: Type 316 stainless steel.
3. Fan Wheel:
    a. Centrifugal, one-piece, blade type as scheduled.
    b. Forward-Curved Fans:
        1) DWDI forward curved fan wheel.
        2) Shallow blades with inlet and tip curved forward in direction of airflow, metal construction, mechanically secured to backplate and inlet flange.
    c. Backward Inclined Fans:
        1) DWDI backward inclined fan wheel.
        2) Nonoverloading performance characteristics.
        3) Backward inclined blades, heavy gauge metal construction, continuously welded to backplate and curved inlet flange.
    d. Airfoil Fans:
        1) DWDI backward inclined fan wheel.
        2) Nonoverloading performance characteristics.
        3) Backward inclined blades, hollow die-formed airfoil design, heavy gauge metal construction, continuously welded to backplate and smooth curved inlet flange.
    e. Plenum Fans:
        1) SWSI backward inclined fan wheel.
        2) Nonoverloading performance characteristics.
        3) Backward inclined blades, hollow die-formed airfoil design, heavy gauge metal construction, continuously welded to backplate and smooth curved inlet flange.
    f. Material: Aluminum.
    g. Attached to fan shaft with split taper lock bushing.

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4. Fan Shaft, Bearings, Drive:
    a. Shafts:
        1) Turned, ground, and polished carbon steel.
        2) Ends drilled and countersunk for tachometer readings.
        3) Keyed for sheave installation.
        4) Coated with lubricating oil.
    b. Bearings:
        1) Grease lubricated, precision anti-friction ball, self-aligning type.
        2) Mounted in cast iron pillow block housing.
        3) Selected for average life (ABMA 9 L_{50}) of not less than 200,000 hours operation at maximum cataloged operating speed.
    c. Drives:
        1) In accordance with Article Fan Drives.
        2) Factory set to specified fan revolutions per minute.
        3) Type: Belt.
        4) Arrangement: 3.
5. Internal Vibration Isolation:
    a. Fan/Motor Base: Isolate base from unit casing with open spring isolators with 2-inch deflection.
    b. Flexible Connectors: Install flexible neoprene coated canvas ducts between fan and unit casing to ensure complete isolation.
6. Accessories:
    a. Extended Lubrication Lines: For any bearing requiring lubrication, grease lines shall be extended to fan support bracket on drive side.
    b. Fan Drive Belt Guard:
        1) Unit shall be provided with an OSHA-approved galvanized, expanded-metal belt guard that totally encloses the drive.
        2) Belt guard shall be rigidly attached to the bearing support structure and have a removable front panel.
        3) A tachometer hole shall be provided opposite the fan shaft.
        4) Guard shall be of a universal size to accommodate any applicable drive configuration.
    c. Plenum Fan Guard Screen: Plenum-type fan section shall be provided with an expanded-metal guard screen for access door.

F. Electric Heating Coil Module:

1. General:
    a. Electric blast-type coil process heater, of low-watt density design.
    b. Casing constructed in accordance with Article Module Casing.
    c. Air pressure drop through heaters 0.25-inch WC maximum.

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d. Electric heaters shall be UL or ETL listed for zero clearance and 100,000 cycles of operation, and shall meet all applicable NEC requirements.
e. UL listed for 100,000 cycles of operation.
f. Elements supported in aluminized steel frame.
g. Element assembly furnished with mounting flanges, allowing individual element removal from terminal box.
h. Stainless steel terminal bolts, nuts, and washers.
i. Heaters with more than one stage shall have each stage cover the full face area of heater.

2. Construction:
   a. Coil Type:
   b. Finned Tubular:
      1) Finned tubular configuration.
      2) Resistance Wire Material: 80 percent nickel/20 percent chromium, Type A.
      3) fins, helically wound onto tube.
      4) Tube filled with granular magnesium oxide, with resistance wire precisely centered.
      5) Silicon rubber end seals.
3. Electrical/Controls:
   a. Magnetic Contactors: Built-in, with 120-volt holding coils.
   b. Wiring:
      1) Stranded copper, 105 degrees F insulation, terminated with crimped connectors or boxed lugs.
      2) Terminals:
         a) Line and control wiring factory prewired to terminal strips for line and control connections.
         b) Clearly labeled.
   c. Fusing: Integral fuse blocks with fusing in each leg of each circuit for heater drawing more than 48 amps.
   d. Heat Stage Control:
   e. Safeties:
      1) Over-temperature protection.
      2) Integral differential pressure type airflow safety switch.
      3) Manual reset thermal cutouts, wired to directly de-energize heater load.
      4) Automatic reset thermal cutouts, wired into control circuit.
      5) Over current protection, where required by UL or NEC.
   f. Panelboard: All electrical/control components housed in Panelboard, NEMA Type,
4. Manufacturers:
   a. Indeeco.
   b. Brasch.

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G. Refrigerant Coil Section:

1. General:
    a. Fin-tube direct expansion refrigerant cooling coil, complete with refrigerant controls, and related accessories.
    b. Casing constructed in accordance with Article Unit Casing.
    c. AHRI 410 performance rated and certified.
    d. Factory tested with air at 300 psig while immersed in an illuminated water tank.
    e. Designed and tested in accordance with ASHRAE 15.
    f. Coil shipped with end connections sealed and filled with a charge of dry nitrogen.
    g. Coils designed for use with refrigerant type in associated refrigerant compressor.
2. Pipe Chase:
    a. All piping and piping mounted controls located in pipe chase.
    b. Chase construction and insulation as for unit.
    c. Internal or External to unit casing.
    d. Adequately sized access door(s) for installation and maintenance of piping.
3. Coil Assembly:
    a. Refrigerant Piping Connections:
        1) On same side of unit.
        2) Extended a minimum of 5 inches beyond exterior of the unit casing by manufacturer.
    b. Coils removable from the unit at header end, unless shown otherwise on Drawings.
    c. Clearly label liquid and suction headers on outside of unit.
4. Refrigerant Circuiting:
    a. Row split intertwined, multiple distributor arrangement.
    b. Alternate tube circuited in order to distribute the cooling effect over the entire coil face at reduced load conditions.
    c. Refrigerant Distributors: Brass, replaceable nozzle type, connected to the coil by copper tubes.
5. Fins:
    a. Die-formed plate type, rippled for maximum heat transfer.
    b. Continuous metal across coil casing; split fins not acceptable.
    c. Shall have fully drawn collars and be mechanically bonded to tubes by mechanical expansion of tubes.
    d. Material: 0.006-inch aluminum.
    e. Fin density no greater than 12 fins per inch.
6. Tubes:
    a. Material: 5/8-inch OD by 0.025-inch wall seamless copper tubing.
    b. Return Bends: Replaceable, brazed joints, 0.049-inch wall thickness.

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c. Intermediate tube supports shall be supplied on coils over 44-inch fin length with an additional support every 42-inch multiple thereafter.

7. Headers:
   a. Located inside unit.
   b. Constructed from seamless copper tubing with die formed tube holes and brazed joints.
   c. Refrigerant Piping Connections: Terminate with OD sweat copper.
8. Casings:
   a. Construct from minimum 16-gauge (0.0625 in.) G-90 galvanized steel with corrosive resistance.
   b. Formed end supports and top and bottom channels.
9. Drain Pan:
   a. Construction in accordance with Paragraph, Drain Pans.
   b. Furnish drain pan under each cooling coil.
   c. Intermediate Drain Pan:
      1) Provide intermediate drain pans on stacked cooling coils.
      2) Intermediate pan shall drain to main drain pan through a copper downspout.
10. Electrical/Controls:
    a. Hot Gas Bypass:
       1) Provide for each refrigeration circuit.
       2) Includes bypass valve and piping, factory installed and piped.
       3) Hot gas bypass inlet at refrigerant distributor.
    b. Thermal Expansion Valve: Factory installed, with remote bulb field mounted.
11. Accessories:
    a. Coil Protective Coating:
       1) Provide factory applied corrosion protection coating on these coil components:
          a) Coil assembly, including all exterior surfaces of fins and tubes.
          b) Refrigerant piping, headers, distributors, exposed to the air stream.
          c) Coil casings.
       2) Coating system type shall be factory dip-applied, in accordance with Article Coil Protective Coating.

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H. Unit Access:

1. Unit access to allow improved access to air handling internal components.
2. Casing constructed in accordance with Article Unit Casing.
3. Double wall, hinged, removable access doors on one side of unit.

I. Filters:

1. General:
   a. Air filtration section, complete with filter media and filter racks.
   b. Casing constructed in accordance with Article Unit Casing.
   c. Double wall, hinged, removable access doors on both side of unit.
   d. Maximum 500 fpm face velocity across filters.
2. Media Schedule:
   a. Prefilter: Angled V-bank arrangement.
3. Media Construction:
   a. General:
      1) Contain in a rigid frame.
      2) Meet UL Class 2 standards.
      3) Rigid supporting mesh across the leaving face of media.
      4) Quality certified by ISO 9001.
   b. Disposable Pleated Type:
      1) Pleated panel disposable filters.
      2) Nonwoven reinforced cotton/poly fabric media with a metal support grid and heavy-duty beverage board-enclosing frame.
      3) 2-inch thickness.
      4) MERV 8 efficiency per ASHRAE 52.2.
      5) Minimum 30 percent dust spot efficiency and 90 percent average arrestance in accordance with ASHRAE 52.1.
   c. Rigid Cartridge Type:
      1) Rigid self-supporting extended surface disposable filters.
      2) Consisting of high density synthetic media, media support grid, metal contour stabilizers, metal diagonal support bracing and enclosing frame.
      3) Media shall be three-ply, dual stage synthetic. Prefilter layer of coarse 7-micron to 10-micron synthetic fibers; secondary ply of progressively structured spun bonded polypropylene fibers blended with filaments from 1 micron to 6.7 microns; and final ply of spun bonded polypropylene backing with strength to support filtering stages.
      4) Media shall withstand 100 percent humidity and be nonshedding.
      5) MERV 13 efficiency per ASHRAE 52.2.

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4. Frame and Filter Assembly:
    a. Suitable for space indicated.
    b. Permanent reusable, side-loading aluminum holding frame, retainer, and sealer frame.
    c. Filter blank-offs to prevent air bypass around filters, same material as frame.
5. Manufacturers:
    a. Farr.
    b. Flanders.
    c. Tri-Dim.
    d. American Air Filter.

J. Mixing Box Section:

1. General: Mixing and control of up to 80 percent return air and 20 percent outside air streams.
2. Include parallel blade control dampers on return and outside air inlets.
3. Set damper blades to merge air streams inside unit.
4. Position dampers blades across short dimension of each air opening.
5. Linkages arranged so corresponding outside and return air dampers move together.
6. Install damper linkage at factory to provide minimum and maximum damper segments proportional to required quantities of minimum and maximum outside air.
7. Damper Construction: In accordance with Article Control Dampers.

K. Outside Air Intake:

1. Weather Hood: Fully welded construction, fabricated from same material as unit casing.
2. Louver: Drainable type, S-shaped rainproof blades, spaced 2 inches maximum.
3. 1/2-inch mesh PVC-coated galvanized bird screen on inside face of louver.

L. Control Dampers:

1. Internally mounted ultra low leak dampers.
2. Parallel blade action.
3. Construction:
    a. Extruded aluminum blades.
    b. Galvanized steel frame, U-shaped galvanized metal sections securely screwed or welded to unit chassis.
    c. Vinyl blade seals, stainless steel jam seals.
    d. Type 304 stainless steel linkage, shafts, and hardware.
    e. Type 304 stainless steel sleeve bearings.

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4. Performance: Leakage rate shall not exceed 5 cfm per square foot at 1 inch-WC and 9 cfm per square foot at 4-inch WC.

M. Unit Electrical and Controls:

1. General:
   a. Electrical and control components shall meet requirements of Division 26 Electrical.
   b. All electrical and controls components and assemblies UL or ETL listed and labeled.
   c. Factory wired units shall bear an ETL or UL label with all necessary identification marks, electrical data, and cautions, as required by NEC.
   d. Provide as-built wiring diagrams and schematics for electrical and control systems, secured to inside of control panel door, or enclosed in plastic jackets placed inside control panel.
   e. For additional requirements, refer to Specification paragraphs for individual sections and components, and Section 23 09 00, Instrumentation and Control Devices for HVAC.
2. Main Power Connection: Provide single point power connection to unit, serving both primary unit voltage and unit control voltage.
3. Main Control Panel:
   a. Provide unit main control panel, with electrical and control components housed in a single enclosure, integral to unit.
   b. NEMA Type 3R enclosure.
   c. Recessed enclosure, exterior flush with unit cabinet, located on unit side.
   d. Compartment ventilated with supply air from unit to provide adequate cooling of components mounted within.
   e. Adequate spare space for field installation of additional electrical and control components.
   f. Access Doors:
      1) Heavy-gauge, insulated, double wall construction, internal sheet metal skin.
      2) Sized and located to provide easy access to unit internal components.
      3) Hinged, latched, and gasketed to provide a weatherproof seal.
4. Factory Installed Adjustable Frequency Drives:
   a. Provide for each motor indicated to be controlled by AFD.
   b. Factory installed **[M: on outside of unit cabinet] [N: in unit Main Control Panel].**
   c. Factory wired to motor terminal box.

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d. NEMA Type 3R enclosure.
e. Comply with requirements of Section 23 05 14, HVAC Adjustable Frequency Drives.

5. Factory Installed Disconnects:
   a. Provide main electric power lockable disconnect for unit.
   b. Provide electric power lockable disconnect for each section containing electrical components.
   c. NEMA Type 3R enclosure.
   d. Nonfused type.
   e. Factory installed on outside of unit cabinet, and factory wired to electrical component terminals.
6. Electrical Convenience Outlets:
   a. Duplex type, 120V, factory installed and wired.
   b. Location:
      1) On exterior of unit, next to each fan section access door.
      2) Inside unit Main Control Panel.
7. Control Damper Actuators:
   a. To suit factory installed control dampers.
   b. Type: Electric, 120V, factory installed, and wired to junction box.
   c. Manufacturer: Belimo.
8. Factory Installed Control System.
9. Integral Motor Control System:
   a. Provide a complete system of motor control for unit motors, including but not limited to:
      1) Terminal blocks.
      2) Motor contactors.
      3) Motor overload protection.
      4) Grounding lugs.
      5) Control transformers.
      6) Auxiliary contactors and terminals for connection of external control devices or relays.
   b. Components located in unit Main Control Panel.
10. Fire Alarm: Circuits (where required) shall be powered from a relay in the unit circuitry.

N. Accessories: Provide where scheduled in Equipment Schedule. As follows.

1. Corrosion Protection Coating:
   a. Provide factory applied corrosion protection coating on these unit components:
      1) Fan wheel (or propeller).
      2) Fan housing.
      3) Fan accessories.
      4) Interior surfaces in contact with air stream.
      5) Exterior cabinet.

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b. Coating system shall be baked enamel.
c. Coating system shall be in accordance with Section 09 90 00, Painting and Coating.

O. Manufacturers and Products:

1. Aerovent; BT.
2. LJ Wing; Genex.
3. Logic Air; LMU.
4. Rapid Engineering; Series 8000.

2.08 MOTORS

A. General:

1. Fan motors shall comply with provisions of Section 26 20 00, Low-Voltage AC Induction Motors.
2. Provide integral manual reset overload protection on single-phase motors. Provide IEEE 841 motor, unless noted otherwise.
3. Motors for fans specified for use with variable frequency drives shall be inverter duty type.
4. Fan motors shall not operate into service factor in any case.

B. Motor requirements shall be as follows unless designated otherwise on fan equipment schedule:

1. Torque Characteristics: Sufficient to accelerate driven loads satisfactorily.
2. Winding Thermal Protection: None.
3. Space Heater: No.
4. Number of Speeds: Single.
5. Number of Windings: One.
6. Motor Efficiency: Premium efficient.
7. Shaft Type: Solid, carbon steel.
8. Mounting: As required for fan arrangement.

2.09 CORROSION PROTECTION

A. General:

1. Factory applied corrosion protection coating for application to unit components and accessories, where in required by this Section.
2. Quality Control:
   a. Verify dry film thickness before final baking.
   b. Finished coating system shall be free from voids, checks, cracks and blisters.

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3. Surface Cleaning: For all coating systems, parts to be coated shall be cleaned as follows:
    a. Immerse parts in heated cleaning solution to remove lubricants, machining oils, and residual factory contamination.
    b. Follow with immersion in potable water bath to neutralize and remove cleaning solution.
    c. Chemical Pretreatment: Immerse parts in heated chemical solution, iron phosphate for steel, clear/yellow chromate for aluminum.

B. Baked Enamel:

1. Material: Alkyd modified urea-melamine single component baking enamel.
2. Surface Preparation: Clean surface to SSPC SP 3, Power Tool Cleaning.
3. Application: Standard air-pressurized spray equipment.
4. Curing: Oven baked at a metal temperature not to exceed 300 degrees F.
5. Finished Thickness: 1 mil to 2 mils, dry film thickness.
6. Performance: Coating shall meet or exceed following criteria:
    a. Impact Resistance: 10 in. lbs, ASTM D2794 test method.
    b. Pencil Hardness: 2H, ASTM D3363 test method.
    c. UV Resistance: UV inhibited life of minimum 10 years when exposed to sun in State of Florida.
    d. Maximum Service Temperature: 230 degrees F, continuous.

C. Baked Polyester:

1. Material: Polyester.
2. Surface Preparation: Sandblast surface to SSPC SP 5.
3. Application: Electrostatic spray.
4. Curing: Oven baked at a metal temperature not to exceed 400 degrees F.
5. Finished Thickness: 1.5-mil to 2.5-mil dry film thickness.
6. Performance: Coating shall meet or exceed following criteria:
    a. Salt Spray Test: Minimum 1,000-hour duration, ASTM B117 test method.
    b. Humidity Resistance: Minimum 1,000-hour duration, ASTM D2247 test method.
    c. Impact Resistance: 100 inch pounds, ASTM D2794 test method.
    d. Pencil Hardness: 2H, ASTM D3363 test method.
    e. UV Resistance: UV inhibited life of minimum 10 years when exposed to sun in State of Florida.
    f. Service Temperature: Maximum 230 degrees F, continuous.

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D. Air-Dry Epoxy:

1. Material: Two-part catalyzed epoxy.
2. Surface Preparation: Clean surface to SSPC SP 3.
3. Application: Standard air-pressurized spray equipment.
4. Curing: Air dry.
5. Finished Thickness: 4-mil to 6-mil dry film thickness.
6. Performance: Coating shall meet or exceed following criteria:
    a. Salt Spray Test: Minimum 1,500-hour duration, ASTM B117 test method.
    b. Pencil Hardness: H-2H, ASTM D3363 test method.
    c. UV Resistance: UV inhibited life of minimum 10 years when exposed to sun in State of Florida.
    d. Service Temperature: Maximum 150 degrees F, continuous.

E. Baked Epoxy:

1. Material: Epoxy.
2. Surface Preparation: Sandblast surface to SSPC SP 10.
3. Application: Electrostatic spray.
4. Curing: Oven baked at a metal temperature not to exceed 400 degrees F.
5. Finished Thickness: 2.5-mil to 3.5-mil dry film thickness.
6. Performance: Coating shall meet or exceed following criteria:
    a. Salt Spray Test: Minimum 1,000-hour duration, ASTM B117 test method.
    b. Humidity Resistance: Minimum 1,000-hour duration, ASTM D2247 test method.
    c. Impact Resistance: 100 inch pounds, ASTM D2794 test method.
    d. Pencil Hardness: 2H, ASTM D3363 test method.
    e. UV Resistance: UV inhibited life of minimum 10 years when exposed to sun in State of Florida.
    f. Service Temperature: Maximum 230 degrees F, continuous.

F. Air Dry Phenolic:

1. Material:
    a. Phenolic resin, Heresite VR-500 Series.
    b. For outdoor applications, apply UV-resistant topcoat, Heresite UC-5500.
2. Surface Preparation: Sandblast surface to SSPC-SP 6.
3. Application: Standard air-pressurized spray equipment.
4. Curing: Air dry.
5. Finished Thickness: 4-mil to 6-mil dry film thickness.
6. Performance: Coating shall meet or exceed following criteria:
    a. Salt Spray Test: Minimum 500-hour duration, ASTM B117 test method.

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b. Humidity Resistance: Minimum 500-hour duration, ASTM D2247 test method.
c. UV Resistance: UV inhibited life of minimum 10 years when exposed to sun in State of Florida.
d. Service Temperature: Maximum 180 degrees F, continuous.

G. Baked Phenolic:

1. Material: Phenolic resin, Heresite P-403.
2. Surface Preparation: Sandblast surface to SSPC SP 5.
3. Application: Standard air-pressurized spray equipment.
4. Curing: Oven baked at a metal temperature not to exceed 400 degrees F.
5. Finished Thickness: 5-mil to 7-mil dry film thickness.
6. Performance: Coating shall meet or exceed following criteria:
   a. Salt Spray Test: Minimum 1,000-hour duration, ASTM B117 test method.
   b. Humidity Resistance: Minimum 1,000-hour duration, ASTM D2247 test method.
   c. Impact Resistance: 100 inch pounds, ASTM D2794 test method.
   d. Pencil Hardness: 2H, ASTM D3363 test method.
   e. UV Resistance: UV inhibited life of minimum 10 years when exposed to sun in State of Florida.
   f. Service Temperature: Maximum 250 degrees F, continuous.

H. Baked Epoxy Phenolic:

1. Material:
   a. Baking cross-linked epoxy-phenolic.
   b. For outdoor applications, apply an UV resistant topcoat.
2. Surface Preparation: Sandblast surface to SSPC SP 5.
3. Application: Electrostatic or conventional compressed air spray equipment.
4. Curing: Oven baked at a metal temperature not to exceed 400 degrees F.
5. Finished Thickness: 6-mil to 8-mil dry film thickness.
6. Performance: Coating shall meet or exceed following criteria:
   a. Salt Spray Test: Minimum 1,000-hour duration, ASTM B117 test method.
   b. Humidity Resistance: Minimum 1,000-hour duration, ASTM D2247 test method.
   c. Impact Resistance: 160 inch pounds, ASTM D2794 test method.
   d. Pencil Hardness: 3H, ASTM D3363 test method.
   e. UV Resistance: UV inhibited life of minimum 10 years when exposed to sun in State of Florida.
   f. Service Temperature: Maximum 350 degrees F, continuous.

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2.10 COIL PROTECTIVE COATING

A. General:

1. Factory dip-applied protective coating for application to plate fin and tube coils.
2. Coil factory assembled and tested before coating application.
3. Coating suitable for coils with maximum 30 fins per inch fin density. Bridging of product across coil fins is unacceptable.
4. After application and proper curing, product shall endure bending of coil assembly in standard manufacturing process without cracking.
5. Apply coating to coil before final factory assembly of equipment. Coating process that requires disassembly of equipment for removal of coil to be coated is not acceptable.

B. Coating Material:

1. Use one of the following materials:
   a. Epoxy Modified Phenolic. Straight phenolic materials are not acceptable.
   b. Epoxy or epoxy-urethane.
   c. Polyelastomer: Complex chain linked polyelastomer material.

C. Coating Process:

1. Coil Inspection and Sealing:
   a. Inspect coil for open tubes, headers, capillary tubes; repair as necessary.
   b. Fill with dry nitrogen, cap and seal, to prevent contamination of internal coil surfaces with cleaning or coating solutions.
2. Coil Cleaning:
   a. Immerse coil in heated alkaline cleaning solution to remove lubricants, machining oils, and residual factory contamination.
   b. Followed with immersion in potable water bath to neutralize and remove cleaning solution.
3. Coating Application:
   a. Immerse coil assembly in coating bath, including headers, casing, and heat exchange surfaces.
   b. Coil shall be completely removed from equipment during coating application.
   c. Spray-on coatings are not acceptable.
4. Curing: Oven baked at a metal temperature not to exceed 400 degrees F.
5. Quality Control: Free from voids, checks, cracks and blisters.

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D. Performance:

1. Coil finish shall meet or exceed the following criteria:
   a. Salt Spray Test: In accordance with ASTM B117, minimum 3,000-hour duration, with no fin corrosion or degradation.
   b. Thermal Efficiency: Loss no greater than 1 percent after coating application.
   c. Exposure to UV Light: UV inhibited life of minimum 10 years when exposed to sun in the State of Florida.

E. Manufacturers and Products:

1. Aero-Marine Engineering Inc.; Technicoat 10-1.
2. AST ElectroFin Inc; ElectroFin.
3. **[A: Bronzglow; Husky® Coil Coat (HLF 815C659).]**

2.11 ACCESSORIES

A. Equipment Identification Plates: Furnish 16-gauge Type 316 stainless steel identification plate securely mounted on each separate equipment component and control panel in a readily visible location. Plate shall bear 3/8-inch high engraved block type **[G: black enamel filled]** equipment identification number and letters indicated in this Specification and as shown.

B. Lifting Lugs: Furnish suitably attached for equipment assemblies and components weighing over 100 pounds.

2.12 SOURCE QUALITY CONTROL

A. Factory Tests and Adjustments: Test equipment actually furnished.

B. Testing Provisions:

1. Provide tachometer access holes large enough to accept standard tachometer drive shaft.
2. Center punch fan shaft to accommodate tachometer readings.

C. Manufacturer’s Tests:

1. Electric Heating Coil Test: 2,000-volt dielectric test.
2. DX Coil Test: Leak tested under water with 300 psi air.
3. Electrical Circuits:
   a. Tested and checked as to proper function.
   b. Perform dielectric strength test.
4. Air Handling Unit Cabinet Tests:
   a. Air Pressure Leak Testing: For modules under positive pressure located on discharge side of a fan, maximum permissible air

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leakage shall not exceed one percent of specified airflow, when subject to 8-inch water gauge differential pressure.

b. Panel Deflection Testing: For modules under negative pressure located on the suction side of the fan, maximum permissible panel deflection shall not exceed 1/200th of panel length, when subject to 8-inch water gauge differential pressure.

c. Leakage Test Failure Guarantee: Upon completion of leakage test, if unit does not meet specified performance for deflection or leakage, Owner may elect to have unit modified to meet specified performance or may request a credit according to performance failure.

D. Acoustical Test:

1. Perform factory noise tests in accordance with AMCA 300 and AMCA 301.
2. Fan sound power levels (dB, Reference 10^{-12} Watts) shall be no greater than scheduled values.

E. Balancing:

1. Completed fan assemblies shall be dynamically balanced to minimum grade of G 6.3 per AMCA 204 at design operating speed.
2. Fans controlled by variable frequency drives shall be dynamically balanced at speeds 25 percent, 50 percent, 75 percent, and 100 percent of design RPM.

F. Vibration Test:

1. Each fan furnished with a 5-hp or larger motor shall have factory run vibration test, including vibration signatures taken on each bearing in horizontal, vertical, and axial direction.
2. Vibration reading as measured at fan scheduled rotational speed shall not exceed the following values when fan is rigidly mounted:
   a. Belt Drive (except Vane Axial): 0.15 in/sec peak velocity.
   b. Belt Drive Vane Axial: 0.08 in/sec peak velocity.
   c. Direct Drive: 0.08 in/sec peak velocity.
   d. Written records of run test and vibration test shall be made available upon request.

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PART 3 EXECUTION

3.01 INSTALLATION

A. Install units level and plumb.

B. Install floor-mounted units on concrete bases designed to withstand, without damage to equipment, the seismic force required by code.

C. Secure vibration controls to concrete bases using anchor bolts cast in concrete base.

D. Inspect internal casing insulation, seal all exposed edges, and butt joints with mastic to ensure insulation will not be loosened during operation.

E. All condensate drain connections piped and trapped separately for proper drainage.

F. Labeling: In accordance with Article Accessories.

G. Service Access: Locate units to provide access spaces required for filter changing; motor, drive, and bearing servicing; and fan shaft and coil removal.

H. Equipment Restraints:

1. Restrain equipment against seismic forces as required by Code.
2. Restrain equipment against wind loads as required by Code.
3. Refer to Section 23 05 48, Vibration Isolation.
4. Seismic Restraint Snubbers:
    a. Rubber-faced, securely anchored to floor or structure.
    b. Install with sufficient clearance so unit isolators are not restricted for proper free isolation, but do limit movement in all directions.

I. Connections:

1. Isolate sheet metal duct connections from all noninternally spring-isolated fan units or other rotating equipment.
2. Install ductwork adjacent to fans so as to allow proper service and maintenance.
3. Pipe drain pan connection through trap running to floor drain.

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3.02 FIELD QUALITY CONTROL

A. Functional Tests:

1. Verify shipping blocking and bracing are removed.
2. Verify unit is secure on mountings and supporting devices, and connections to ducts and electrical components are complete.
3. Verify proper thermal-overload protection is installed in motors, starters and disconnect switches.
4. Verify cleaning and adjusting are complete.
5. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation.
6. Reconnect fan drive system, align and adjust belts and install belt guards.
7. Verify lubrication for bearings and other moving parts.
8. Verify manual and automatic volume control and fire and smoke dampers in connected ductwork are in fully open position.

B. Performance Tests:

1. Starting Procedures:
   a. Energize motor and adjust fan to indicated rpm.
   b. Measure and record motor voltage and amperage.
2. Operational Test:
   a. After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   b. Repair or replace malfunctioning units; retest as specified after repairs or replacement is made.
   c. Test and adjust control safeties.
   d. Replace damaged and malfunctioning controls and equipment.

3.03 ADJUSTING

A. Adjust damper linkages for proper damper operation.

B. Adjust belt tension.

C. Lubricate non-sealed bearings prior to startup.

D. Air Balancing:

1. Perform air system balancing as specified in Section 23 05 93, Testing, Adjusting, and Balancing for HVAC.
2. Replace fan and motor sheaves as required to achieve design airflow.

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E. Vibration Testing:

1. Perform field testing on rotating equipment, where specified in Section 23 05 93, Testing, Adjusting, and Balancing for HVAC, to determine actual operating vibration.
2. If vibration limits described therein are exceeded, rebalance equipment in-place until design tolerances are met.

3.04 CLEANING

A. On completion of installation, internally clean fans according to manufacturer's written instructions. Remove foreign material and construction debris. Vacuum fan wheel and cabinet.

B. After completing system installation, including outlet fitting and devices, inspect exposed finish. Remove burrs, dirt, and construction debris, and repair damaged finishes.

3.05 MANUFACTURER'S SERVICES

A. Provide manufacturer's representative at site in accordance with Section 01 43 33, Manufacturers' Field Services, for installation assistance, inspection and certification of proper installation, equipment testing, startup assistance, and training of Owner's personnel for specified component, subsystem, equipment, or system.

B. Manufacturer's Representative: Present at Site or classroom designated by **[A: Owner,] [B: ,]** for minimum person-days listed below, travel time excluded:

1. **[C:]** person-days for **[D: installation assistance] [E: and] [F: inspection]**.
2. **[G:]** person-days for **[H: functional] [I: and] [J: performance]** testing and completion of Manufacturer's Certificate of Proper Installation.
3. **[K:]** person-days for pre-startup classroom or site training.
4. **[L:]** person-days for facility startup.
5. **[M:]** person-days for post-startup training **[N: of Owner's personnel].**
6. **[O: Training shall not commence until an accepted detailed lesson plan for each training activity has been reviewed by [P: Owner] [Q: Engineer] [R:].]**

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C. Refer **[A: Section 01 43 33, Manufacturers' Field Services] [B: and] [C: Section 01 91 14, Equipment Testing and Facility Startup].**

END OF SECTION

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AIR HANDLING UNITS 23 77 00.01

SYMBOL							
TYPE							
LOCATION							
SUPPLY FAN MODULE	AIRFLOW	MAX	CFM				
		MIN	CFM				
		OSA	CFM				
		TSP	IN WG				
		ESP	IN WG				
	MAX. POWER		BHP				
	FAN SPEED		RPM				
	WHEEL TYPE						
	DRIVE						
	FAN MOTOR DATA	H.P.					
		SPEED	RPM				
		VOLT					
		PH					
		MOTOR ENCL.					
SUPPLY FAN SOUND DATA	MAX. FAN DISCHARGE SOUND POWER LEVEL dB (RE 10-12 W) @ MID OCTAVE BAND FREQUENCY (Hz)		63				
			125				
			250				
			500				
			1K				
			2K				
			4K				
			8K				
DX COOLING COIL MODULE	CAPACITY	TOTAL	MBH				
		SENS.	MBH				
	ROWS						
	FINS PER INCH						
	AIRSIDE	FLOW	CFM				
		EAT	DB				
		DEG. F	WB				
		LAT	DB				
		DEG. F	WB				
		DELTA P	IN. WG.				
		TXV	SIZE				
			#				

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AIR HANDLING UNITS 23 77 00.01

SYMBOL							
CHILLED WATER COOLING COIL MODULE	CAPACITY	TOTAL	BTU/H				
		SENS.	BTU/H				
	ROWS						
	FINS PER INCH						
	AIRSIDE	FLOW	CFM				
		EAT	DB				
		DEG. F	WB				
		LAT	DB				
		DEG. F	WB				
		DELTA P	IN. WG.				
	WATER SIDE	FLOW	GPM				
		FLUID	TYPE				
			%				
		VALVE	SIZE				
			Cv				
		EWT	DEG. F				
		LWT	DEG. F				
		DELTA P	FT. H2O				
HOT WATER HEATING COIL MODULE	CAPACITY		MBH				
	ROWS						
	FINS PER INCH						
	AIRSIDE	FLOW	CFM				
		EAT	DEG. F				
		LAT	DEG. F				
		DELTA P	IN. WG.				
	WATER SIDE	FLOW	GPM				
		FLUID	TYPE				
			%				
		VALVE	SIZE				
			Cv				
		EWT	DEG. F				
		LWT	DEG. F				
		DELTA P	FT. H2O				

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AIR HANDLING UNITS 23 77 00.01

SYMBOL						
ELECTRIC HEATING COIL MODULE	COIL TYPE					
	CAPACITY	kW				
	AIRFLOW	CFM				
	EAT	DEG. F				
	LAT	DEG. F				
	STEPS					
	VOLT					
	PH					
	HEATER CONTROL					
FILTER MODULE	EFFICIENCY %	PRE				
		FINAL				
	SIZE & QUANTITY					
	RESISTANCE (FINAL)	IN. WG.				
MAXIMUM DIMENSIONS	PHYSICAL SIZE INCHES	L				
		W				
		H				
	WEIGHT	LBS				
MANUFACTURER AND MODEL NO.						
APPLICABLE REMARKS						

ABBREVIATIONS:

FC: FORWARD CURVED
BI: BACKWARD INCLINED
PLUG: PLUG OR PLENUM FAN
AF: AIR FOIL
EG: ETHYLENE GLYCOL
PG: PROPYLENE GLYCOL

REMARKS:

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MAKE-UP AIR HANDLING UNITS 23 77 00.02

SYMBOL							
TYPE							
LOCATION							
FAN MODULE	AIRFLOW	SUPPLY	CFM				
		OSA	CFM				
	STATIC PRESSURE	TOTAL	IN. WG.				
		EXT.	IN. WG.				
	MAX. POWER		BHP				
	FAN SPEED		RPM				
	WHEEL TYPE						
	DRIVE						
	FAN MOTOR DATA	H.P.					
		SPEED	RPM				
		VOLT					
		PH					
		MOTOR ENCL.					
ELECTRIC HEATING COIL MODULE	COIL TYPE						
	CAPACITY		kW				
	AIRFLOW		CFM				
	EAT		DEG. F				
	LAT		DEG. F				
	STEPS						
	VOLT						
	PH						
	HEATER CONTROL						
	AIR DP @ MAX CFM		IN. WG.				
GAS FIRED HEATER MODULE	FUEL SOURCE						
	GAS INPUT		MBH				
	HEAT OUTPUT		MBH				
	AIRFLOW		CFM				
	EAT		DEG. F				
	LAT		DEG. F				
	GAS SUPPLY PRESS	MIN	IN. WG.				
		MAX	IN. WG.				
	BURNER	CONTROL TYPE					
		IGNITION TYPE					
	AIR DP @ MAX CFM		IN. WG.				

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MAKE-UP AIR HANDLING UNITS 23 77 00.02

SYMBOL							
EVAPORATIVE COOLING MODULE	TOTAL CAPACITY		MBH				
	AIRFLOW		CFM				
	EAT DEG. F		DB				
			WB				
	LAT DEG. F		DB				
			WB				
	AIR DP @ MAX CFM		IN. WG.				
	MAKEUP WATER		GPM				
	RECIRCULATION PUMP DATA	FLOW	GPM				
		MOTOR	HP				
			VOLT				
			PH				
FILTER MODULE	EFFICIENCY		%				
	RESISTANCE (FINAL)		IN. W.G.				
DIMENSIONS	MAXIMUM PHYSICAL SIZE INCHES		L				
			W				
			H				
	MAXIMUM WEIGHT		LBS				
MANUFACTURER AND MODEL NO.							
APPLICABLE REMARKS							

ABBREVIATIONS:

NG: NATURAL GAS

PG: PROPANE GAS

NG / PG: DUAL FUEL, NATURAL AND PROPANE GAS

REMARKS:

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DUCTLESS SPLIT SYSTEM DX INDOOR UNITS 23 81 00.02

SYMBOL							
LOCATION							
TYPE							
FAN DATA	SUPPLY AIR		CFM				
	OUTSIDE AIR		CFM				
	EXTERNAL STATIC PRESS.		IN W.G.				
DX COOLING DATA	TOTAL		BTU/HR				
	SENS.		BTU/HR				
	ENTERING AIR TEMP.	DEG. F	DB				
		DEG. F	WB				
	COND. TEMP.		DEG. F				
DX HEATING DATA	TOTAL		BTU/HR				
	ENTERING AIR TEMP.	DEG. F	DB				
	COND. TEMP.		DEG. F				
ELECTRIC HEATING DATA	kW						
	STEPS						
	VOLT						
	PH						
FAN MOTOR DATA	FLA						
	VOLT						
	PH						
ELECTRICAL DATA	# CONN.						
	MCA						
	FUSE						
	VOLT						
	PH						
	FACTORY INSTALLED DISCONNECT?						
DIMENSIONS	WIDTH		INCHES				
	DEPTH		INCHES				
	HEIGHT		INCHES				
	MAXIMUM WEIGHT		LBS				
MANUFACTURER							
MODEL NO.							
APPLICABLE REMARKS:							

REMARKS:

A: ELECTRONIC PROGRAMMABLE THERMOSTAT
B: OUTSIDE AIR DUCT CONNECTION
C: WALL MOUNT THERMOSTAT MOUNTING KIT
D: INTERNAL CONDENSATE PUMP
E: FRESH AIR INTAKE AND POWER VENTILATION KIT
F: SUPPLY AIR GRILLE GUARD

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SPLIT SYSTEM DX OUTDOOR UNITS 23 81 00.03

SYMBOL						
SERVING						
DX COOLING DATA	CAPACITY	BTU/HR				
	AMBIENT TEMP.	DEG. F				
	SEER	@ AHRI				
DX HEATING DATA	CAPACITY	BTU/HR				
	COND. TEMP.	DEG. F				
	COP	@ AHRI				
OUTDOOR FAN DATA	NO.					
	H.P. (EA.)					
	VOLT					
	PH					
	CFM (TOTAL)					
COMPRESSOR DATA	NO.					
	STEPS					
	RLA (EA.)					
	LRA (EA.)					
	VOLT					
	PH					
ELECTRICAL DATA	# CONN.					
	MCA					
	MOCP (FUSE)					
	VOLT					
	PH					
DIMENSIONS	LENGTH	INCHES				
	WIDTH	INCHES				
	HEIGHT	INCHES				
	MAXIMUM WEIGHT	LBS				
MANUFACTURER						
MODEL NO.						
APPLICABLE REMARKS:						

REMARKS:

A: CRANKCASE HEATER
B: CONDENSER HAIL GUARDS
C: 5-YEAR COMPRESSOR WARRANTY FOR EACH COMPRESSOR
D: DIP APPLIED ANTI-CORROSION COATING ON CONDENSER COIL (NOT SPRAY APPLIED)
E: COPPER CONDENSER COIL FINS
F: FACTORY INSTALLED UNLOADER ACCESSORY
G: HOT GAS BYPASS ON LEAD COMPRESSOR
H: HOT GAS BYPASS ON BOTH COMPRESSORS
I: FACTORY INSTALLED ACCUMULATOR
J: LOW-AMBIENT COOLING KIT
K: WALL-MOUNT KIT
L: COMPRESSOR START ASSIST
M: CABINET CORROSION PROTECTION
N: COMPRESSOR CYCLE DELAY
O: HOT-GAS REHEAT
P: LIQUID LINE FILTER DRIER
Q: LIQUID SOLENOID VALVE

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SECTION 26 05 02
BASIC ELECTRICAL REQUIREMENTS

PART 1 GENERAL

1.01 RELATED SECTIONS

A. Requirements specified within this section apply to Division 26, Electrical. Work specified herein shall be performed as if specified in the individual sections.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. National Electrical Contractors Association (NECA): National Electrical Installation Standards.
2. National Electrical Manufacturers Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
   b. Z535.4, Product Safety Signs and Labels.
3. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
4. Underwriters Laboratories, Inc. (UL).

1.03 DESIGN REQUIREMENTS

A. **[A: .]**

1.04 ELECTRIC SERVICE DIVISION OF RESPONSIBILITY

A. Underground electrical service facilities provided by the serving utility as part of its normal obligation to customers is work provided outside this Contract. Under this Contract provide customer required service provisions and electrical work including, but not limited to, primary trench and backfill, primary duct system, primary cable and cable terminations, primary switchgear and switchgear pad.

B. Interior telecommunications central and station equipment (telephone instruments, telephone switches, data switches, and hubs, servers, software, etc.) is work provided outside this Contract. Under this Contract provide raceways, outlet and junction boxes, cover plates, pull wires, as indicated.

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1.05 SUBMITTALS

A. Action Submittals:

1. Provide manufacturers' data for the following:
   a. Electrical service components.
   b. Telephone service components.
   c. Nameplates, signs, and labels.

1.06 QUALITY ASSURANCE

A. Provide the Work in accordance with NFPA 70. Where required by Authority Having Jurisdiction (AHJ), material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ, in order to provide a basis for approval under the NEC.

B. Materials and equipment manufactured within the scope of standards published by Underwriters Laboratories Inc. shall conform to those standards and shall have an applied UL listing mark or label.

C. Provide materials and equipment acceptable to AHJ for Class, Division, and Group of hazardous area indicated.

1.07 ENVIRONMENTAL CONDITIONS

A. The following areas are classified hazardous Class I, Division 1, Group D, due to the potential for occurrence of hazardous concentrations of combustible gases, and for exposure to corrosive environment. Use materials and methods required for such areas.

1. None.

B. The following areas are classified hazardous, Class I, Division 2, Group D, due to the potential for accumulation of hazardous concentrations of combustible gases, and for exposure to corrosive environment. Use materials and methods required for such areas.

1. None.

C. The following areas are classified nonhazardous, wet, and corrosive. Use materials and methods required for such areas.

1. Process areas within Chemical Building.
2. **[A:]**.

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D. The following areas are classified nonhazardous and wet. Use materials and methods required for such areas.

1. Outdoor abovegrade areas not covered above.
2. Equipment Room in the Chemical Building.
3. Belowgrade vaults.
4. Filter rooms.
5. Pump rooms.

E. The following areas are classified as indoor and dry:

1. Administration and laboratory spaces.
2. Electrical Rooms.

F. The following indoor areas are not classified. Use dust-tight and oil-tight NEMA 12 materials and methods.

1. Areas not covered above.
2. **[A:]**.

PART 2 PRODUCTS

2.01 GENERAL

A. Where two or more units of the same class of material or equipment are required, provide products of a single manufacturer. Component parts of materials or equipment need not be products of the same manufacturer.

B. Material and equipment installed in heated and ventilated areas shall be capable of continuous operation at their specified ratings within an ambient temperature range of 40 degrees F to 104 degrees F.

C. Materials and equipment installed outdoors shall be capable of continuous operation at their specified rating within the ambient temperature range stated in Section 01 61 00, Common Product Requirements.

D. Equip panels installed outdoors in direct sun with sun shields.

E. Electrical ratings of materials and equipment that are reduced by increased elevation shall be derated as required for Site elevation specified in Section 01 61 00, Common Product Requirements.

2.02 EQUIPMENT FINISH

A. Manufacturer’s standard finish color, except where specific finish or color is indicated. If manufacturer has no standard color, finish equipment in

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accordance with Section 09 90 00, Painting and Coating, light gray color finish as approved by CH2M.

2.03 NAMEPLATES

A. Material: Laminated plastic.

B. Attachment Screws: Stainless steel.

C. Color: White, engraved to a black core.

D. Letter Height:

1. Pushbuttons/selector switches and indicating lights: 1/8 inch.
2. Other electrical equipment: **[C: 1/4] [D: 3/8] [E:]** inch.

2.04 SIGNS AND LABELS

A. Sign size, lettering, and color shall be in accordance with NEMA Z535.4.

PART 3 EXECUTION

3.01 GENERAL

A. Electrical Drawings show general locations of equipment, devices, and raceway, unless specifically dimensioned. Contractor shall be responsible for actual location of equipment and devices and for proper routing and support of raceways, subject to approval of Engineer.

B. Check approximate locations of light fixtures, switches, electrical outlets, equipment, and other electrical system components shown on Drawings for conflicts with openings, structural members, and components of other systems and equipment having fixed locations. In the event of conflicts, notify Engineer in writing.

C. Install work in accordance with NECA Standard of Installation, unless otherwise specified.

D. Keep openings in boxes and equipment closed during construction.

E. Lay out work carefully in advance. Do not cut or notch any structural member or building surface without specific approval of Engineer. Carefully perform cutting, channeling, chasing, or drilling of floors, walls, partitions, ceilings, paving, or other surfaces required for the installation, support, or anchorage of conduit, raceways, or other electrical materials and equipment. Following such work, restore surfaces to original condition.

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3.02 ANCHORING AND MOUNTING

A. Equipment anchoring and mounting shall be in accordance with manufacturer's requirements for seismic zone criteria given in Section 01 61 00, Common Product Requirements.

3.03 COMBINING CIRCUITS INTO COMMON RACEWAY

A. Homerun circuits shown on Drawings indicate functional wiring requirements for power and control circuits. Circuits may be combined into common raceways in accordance with the following requirements:

1. Analog control circuits from devices in same general area to same destination.
    a. No power or AC discrete control circuits shall be combined in same conduit with analog circuits.
    b. No Class 2 or Class 3 circuits including, but not limited to, HVAC control circuits, fire alarm circuits, paging system circuits shall be combined with power or Class 1 circuits.
    c. Analog circuits shall be continuous from source to destination. Do not add TJB, splice, or combine into a multi-pair cable without authorization of Engineer.
    d. Raceways shall be sized per General Circuit and Raceway Schedule and do not exceed 40 percent fill.
    e. Changes shall be documented on record drawings.
2. Discrete control circuits from devices in the same general area to the same destination.
    a. No power or analog control circuits shall be combined in same conduit with discrete circuits.
    b. No Class 2 or Class 3 circuits including, but not limited to, HVAC control circuits, fire alarm circuits, and paging system circuits shall be combined with power or Class 1 circuits.
    c. Raceways shall be sized per the General Circuit and Raceway Schedule and do not exceed 40 percent fill.
    d. Changes shall be documented on record drawings.
3. Power circuits from loads in same general area to same source location (such as: panelboard, switchboard, low voltage motor control center).
    a. Lighting Circuits: Combine no more than three circuits to a single raceway. Contractor shall be responsible for increasing conduit and conductor size if derating is required by NEC.
    b. Receptacle Circuits, 120-Volt Only: Combine no more than three circuits to a single raceway. Provide a separate neutral conductor for each circuit. Contractor shall be responsible for increasing conduit and conductor size if derating is required by NEC.
    c. All Other Power Circuits: Do not combine power circuits without authorization of Engineer.

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3.04 NAMEPLATES, SIGNS, AND LABELS

A. Arc Flash Protection and Shock Hazard Warning Signs:

1. Field mark equipment to warn qualified persons of potential arc flash and shock hazards. Locate marking so as to be clearly visible to persons working on energized equipment. Mark the following equipment and devices.
    a. Medium-voltage switchgear.
    b. Switchboards.
    c. Motor control centers.
    d. Motor starters.
    e. Stand-alone adjustable frequency drives.
    f. Local disconnect switches.
    g. Panelboards.
    h. Mini power centers.
    i. HVAC equipment terminal enclosure.
    j. Heat trace panels.
    k. Package control system panels.
    l. SCADA control panels containing voltages greater than 50V.
2. Use arc flash hazard boundary, energy level, PPE level and description, shock hazard, bolted fault current, and equipment name from Engineer as basis for warning signs.

B. Multiple Power Supply Sign: Install permanent plaque or directory at each service disconnect location denoting other services, feeders, and branch circuits supplying the building, and the area served by each.

C. Equipment Nameplates:

1. Provide a nameplate to label electrical equipment including switchgear, switchboards, motor control centers, panelboards, motor starters, transformers, terminal junction boxes, disconnect switches, switches and control stations.
2. Switchgear, motor control center, transformer, and terminal junction box nameplates shall include equipment designation.
3. “Serves” Nameplates: Provide a “Serves” nameplate to include equipment number (tag number), equipment name and location (room number or other location information) of equipment served by particular electrical devices. Provide “Serves” nameplates for the following:
    a. Switchgear and switchboard feeder circuit breakers.
    b. Motor control center cubicles containing.
        1) Feeder circuit breakers.
        2) Motor starters.
        3) Adjustable frequency drives.
    c. Stand-alone motor starters or adjustable frequency drives.

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d. Local disconnect switches.
e. Transformers.

4. "Served By" Nameplates: Provide a "Served By" nameplate to include equipment number (tag number), circuit number or cubicle location, and location (room number or other location information) of equipment providing power to particular electrical devices. Provide "Served By" nameplates for the following:
   a. Switchgear and switchboard main circuit breakers.
   b. Panelboards.
   c. Stand-alone motor starters or adjustable frequency drives.
   d. Local disconnect switches.
   e. Transformers.
5. Switchboard and panelboard nameplates shall include equipment designation, service voltage, and phases.

3.05 LOAD BALANCE

A. Drawings and Specifications indicate circuiting to electrical loads and distribution equipment.

B. Balance electrical load between phases as nearly as possible on switchboards, panelboards, motor control centers, and other equipment where balancing is required.

C. When loads must be reconnected to different circuits to balance phase loads, maintain accurate record of changes made, and provide circuit directory that lists final circuit arrangement.

3.06 CLEANING AND TOUCHUP PAINTING

A. Cleaning: Throughout the Work, clean interior and exterior of devices and equipment by removing debris and vacuuming.

B. Touchup Paint:

1. Touchup scratches, scrapes and chips on exterior and interior surfaces of devices and equipment with finish matching type, color, and consistency and type of surface of original finish.
2. If extensive damage is done to equipment paint surfaces, refinish entire equipment in a manner that provides a finish equal to or better than factory finish, that meets requirements of Specification, and is acceptable to Engineer.

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3.07 PROTECTION FOLLOWING INSTALLATION

A. Protect materials and equipment from corrosion, physical damage, and effects of moisture on insulation and contact surfaces.

B. When equipment intended for indoor installation is installed at Subcontractor's convenience in areas where subject to dampness, moisture, dirt or other adverse atmosphere until completion of construction, ensure adequate protection from these atmospheres is provided and acceptable to Engineer.

END OF SECTION

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SECTION 26 05 03
PREFABRICATED ELECTRICAL EQUIPMENT BUILDING

PART 1 GENERAL

1.01 SCOPE

A. This specification covers requirements applicable to the provision of a prefabricated electrical equipment building. The building shall be environmentally controlled, and shall consist of a coordinated grouping of electrical power and control equipment as indicated on any accompanying data sheets and/or drawings. Any data sheets, drawings, or any other related documents accompanying or referenced by this Specification shall be considered a part of this Specification.

B. Furnish, install, interconnect, and test the equipment and materials specified herein, as well as any equipment specified in any related documents.

C. Site conditions are given in Section 01 61 00, Common Product Requirements. These conditions shall be considered when sizing and designing equipment and structures.

1.02 REFERENCES

A. All materials, equipment and labor supplied by the supplier shall be in strict compliance with the statutes, codes and standards listed herein. Where conflicts exist between statutes, codes and standards, the more stringent requirement shall prevail. Applicable statutes, codes and standards are as listed below:

1. American Institute of Steel Construction (AISC).
2. American National Standard Institute (ANSI).
3. American Society of Testing and Materials (ASTM).
4. American Welding Society (AWS).
   a. AWSD1.1 Structural Welding Code – Steel.
5. National Fire Protection Association (NFPA).
   a. 70 - National Electric Code (NEC), 2017 edition.
6. National Electrical Manufacturers Association (NEMA).
7. Underwriters' Laboratories (UL).
   a. 752 – Standard for Bullet-Resisting Equipment, 2005 edition.
8. International Building Code (IBC).
9. State Modular Building Code Programs where applicable.

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1.03 SUBMITTALS

A. Action Submittals:

1. Any quality plans, forms, or procedures.
2. Structural drawings including:
    a. General notes.
    b. Building plan with equipment layout.
    c. Building base skid detail.
    d. Building elevations.
    e. Stairs and landings details (if applicable).
    f. Certified anchorage and bracing calculations in accordance with Section 01 88 15, Anchorage and Bracing.
3. Electrical Drawings, including:
    a. Electrical notes.
    b. Building electrical plan, showing conduit, cable tray, subfloor wireway, and any other means of wiring transit. Drawings shall also include conduit fill.
    c. Building services wiring diagrams.
    d. Grounding system plan.
    e. Interconnection wiring diagrams.
    f. Panelboard schedules.

B. Informational Submittals:

1. Final as-built drawings and information for items listed in this paragraph, and shall incorporate all changes made during the manufacturing process.
2. Wiring diagrams.
3. Certified structural calculations (if applicable).
4. Installation information including equipment anchorage provisions.
5. Operation and maintenance instructions for the building and its accessories.

1.04 QUALITY REQUIREMENTS

A. The building shall be manufactured under an established autonomous quality assurance program. The supplier shall have a designated quality assurance (QA) manager.

1. The successful bidder shall be prepared to submit for customer approval, any and/or all quality plans, forms, and procedures applicable to the manufacturer of the building.

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1.05 QUALIFICATIONS

A. The manufacturer of this equipment shall have produced similar electrical equipment for a minimum period of 5 years. When requested by CH2M, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.

1.06 NOMENCLATURE

A. The equipment number (the tag number) of the building is 400. Its name is "Electrical Building." Use this information in the preparation of drawings and submittals.

B. The building will be rectangular. For purposes of these Specifications, the long axis of the building will be oriented north-south. Descriptions of the location of building features or equipment will refer to "north," "south," "east" and "west" walls.

1.07 DELIVERY, STORAGE AND HANDLINE

A. In accordance with Section 01 61 00, Common Product Requirements.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. The building shall be a product of:

1. Eaton.
2. Powell Industries.
3. Schneider Electric (Square D).

2.02 GENERAL

A. The building shall be designed and constructed for outdoor use, under wind and seismic load conditions per the IBC or State guidelines for the job site.

B. The building and all components mounted thereon shall be designed for, and anchored sufficiently for, transportation to the job site.

C. The building shall be of welded construction.

1. Welded construction shall utilize ASTM A36 minimum structural steel members, sized and arranged for proper strength, and able to withstand the stress and loads which will result when lifting the complete factory fabricated and equipped assemblies. Welding shall be in accordance with the requirements of AWSD1.1. All welding shall be performed by

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welders certified for the work being performed. Suppliers shall be prepared to show welders' certificates.

a. Deflection shall be L/240. The building shall be suitable for installation on a concrete pad.
b. The building shall be equipped with two stainless steel ground pads located at opposite corners structural base with provisions for NEMA two-hole pattern lug.
c. The skid shall be provided with a minimum of 8 mils mastic undercoating.

D. The floor shall be a minimum of 1/4-inch H.R. ASTM A36 minimum smooth steel plate, welded to the perimeter and longitudinal and/or transverse structural members of the skid. The floor loading shall be no less than 250 psf.

1. The floor shall be provided with gasketed floor cutouts where required for power and control cable entry/exit from the equipment. The cutouts shall be provided with 12-gauge galvanized or painted coverplates.

E. Building Construction:

1. Building walls, roof and ceiling shall be fabricated from G90 galvanized steel. Exterior walls, exterior roof and interior ceiling shall be self-framing, interlocking design, with maximum panel width of 16-inch, or framed construction with maximum panel width of 36-inch.
2. Exterior walls shall be 18-gauge minimum thickness for self-framing and interlocking design, or 24-gauge minimum thickness framed construction design, but rated to withstand the loading requirements of the job site.
    a. The south and east exterior walls of the building shall be bullet-resistant to conform to the requirements of UL 752, Level 4.
3. Exterior roof shall be 18-gauge thickness for self-framing and interlocking design, or 24-gauge thickness framed construction design, but rated to withstand the loading requirements of the job site. The roof shall be sloped away from the personnel doors, where feasible. Gutters and downspouts shall be provided when the roof slope is directly over personnel or rear access equipment doors.
4. Interior ceiling shall be 18-gauge minimum thickness for self-framing and interlocking design, or 22-gauge minimum thickness framed construction design, but rated to withstand the loading requirements of the job site.

F. For a building which must be shipped in multiple shipping sections, miscellaneous NEMA 1 junction boxes will be provided at the shipping splits for easy breakdown of the building wiring for shipment and reconnection at the job site. Prior to shipment the open end/sides of each shipping section will be crated (weatherproofed) for transit to the job site. The crating must be

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performed by a company recognized and experienced in the trade or by the building manufacturer.

G. Where wall bulkhead penetrations are required, the cutouts shall be completely framed with 1/4-inch aluminum cover plates with neoprene gasket.

H. All fastening hardware shall be zinc plated, stainless steel or aluminum. Welding of galvanized steel and rivets shall not be the primary method of exterior fastening. Rivets may be used for mounting non-load-bearing trim members.

I. Provide two entrance doors. The doors shall be double wall construction, with brushed aluminum panic hardware with cylinder lock and thumb latch, brushed aluminum automatic closure with built-in hold open device, prime coat or stainless steel hinges, threshold, weather-stripping, drip shields/water flashing, "DANGER, HIGH VOLTAGE, KEEP OUT" sign, and a 12-inch removable transom above the north door.

1. The south door shall be 36-inch by 84-inch and shall be bullet-resistant to conform to the requirements of UL 752, Level 4.
2. The north door shall be 48-inch by 84-inch.

J. Provide landings and stairs for the building. The stairs shall be built in compliance with the UBC code, and shall be hot-dipped galvanized after fabrication.

K. For equipment requiring rear access, provide 14-gauge minimum galvanized steel, gasketed and hinged equipment rear access doors, with 3-point latching system with galvanized padlockable handles, "DANGER HIGH VOLTAGE" sign, and drip shields/water flashing.

L. The walls, roof and floor shall be fully insulated, with a minimum of R-11 insulation. The walls and roof shall be provided with fiberglass batt type insulation, minimum R-11. The floor shall be provided with polyurethane spray foam insulation, minimum R-6.

M. The building shall be provided with a paint system per the following:

1. The skid shall be prepared to the appropriate SSPC standard (SSPC-1, SSPC-2, SSPC-3) for removal of rust and scale prior to painting. A 2 to 3 mil application of Zinc rich primer shall be provided.
2. The floor shall be provided with a 2-3 mil application of "Red" epoxy iron oxide primer, followed by a 2-3 mil application of ANSI 61 gray epoxy, with a non-skid finish.
3. The exterior and interior of the building shall be provided with a 0.3 to 0.6 mil application of a vinyl wash primer, followed by a 2 to 3 mil application of white epoxy paint.

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N. As indicated on the one-line diagrams and the Panelboard Schedule.

2.03 ELECTRICAL DISTRIBUTION EQUIPMENT

A. SWGR-400-02 - Low-Voltage Switchgear:

1. Provide in accordance with Section 26 23 00, Low-Voltage Switchgear.
2. Locate along the west wall of the building, to the south end.

B. MCC-400-01 – Motor Control Center:

1. Provide in accordance with Section 26 24 19, Low-Voltage Motor Control.
2. Locate along the west wall of the building, north of SWGR-400-02.

C. ATS-400-01 – Bypass-Isolation Automatic Transfer Switch:

1. Provide in accordance with Section 26 36 23, Bypass-Isolation Automatic Transfer Switches.
2. Locate along the west wall of the building, north of MCC-400-01.

D. PNL-400-01 and PNL-400-02 – Panelboards:

1. Provide in accordance with Section 26 24 16, Panelboards.
2. Locate PNL-400-01 along the west wall of the building, north of ATS-400-01.
3. Locate PNL-400-02 along the east wall of the building, to the south of TR-400-02.

E. TR-400-02:

1. Provide in accordance with Section 26 22 00, Low-Voltage Transformers.
2. Locate along the east wall of the building, toward the north end.

F. UPS-400-01:

1. Provide in accordance with Section 26 33 53, Static Uninterruptible Power Supply.
2. Locate along the east wall of the building, south of PNL-400-02.
3. Ratings: 120V input and output, 2.5 kVA.
4. Ship the batteries separately.

G. Exterior Lighting Control:

1. Provide an electronic programmable time switch in accordance with Section 26 50 00, Lighting.
2. Locate along the east wall of the building.

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2.04 RESERVED SPACE

A. Aisle Space: Provide a minimum of 4 feet clear between the equipment on the east and west walls.

B. Plant automation systems.

C. Fire alarm and security systems equipment.

D. Switchgear battery and battery charger.

2.05 ACCESSORIES

A. HVAC: Provide an HVAC system, sized and provided by the supplier, considering the ambient site conditions, the dimensions of the building, the solar heating of the building, and the heat generated by the equipment within the building. The system shall be designed such that the sensible cooling capacity, NOT the total cooling capacity, will maintain an ambient temperature within the building of between 55 degrees F winter and 75 degrees F summer at design conditions. Provide an electronic, automatic changeover thermostat.

B. Electrical:

1. General: In accordance with Section 26 05 02, Basic Electrical Requirements, and Section 26 05 04, Basic Electrical Materials and Methods.
2. Wiring: In accordance with Section 26 05 05, Conductors.
3. Grounding and Bonding: In accordance with Section 26 05 26, Grounding and Bonding for Electrical Systems:
    a. Provide a 1/4-inch by 2-inch copper ground bar running the length of the building along the east and west walls., Mount the bar on standoff insulators approximately 6 inches below the ceiling. Bond the ground bar to each end of the equipment ground bars in SWGR-400-02 and MCC-400-02. Provide a 4/0 AWG green insulated copper ground cable from the ground bar to the exterior ground pads. Provide a green insulated copper ground wire from the ground bar to all auxiliary electrical equipment sized in accordance with NEC Table 250-122, but not smaller than 6 AWG.

C. Conduit and Boxes: In accordance with Section 26 05 33, Raceway and Boxes.

D. Receptacles and Light Switches: In accordance with Section 26 27 26, Wiring Devices.

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1. Interior receptacles: Provide one receptacle adjacent to each of the building doorways.
2. Exterior Receptacles:
    a. Provide one receptacle along the west wall of the building.
    b. Provide one receptacle adjacent to each piece of HVAC equipment.
3. Light Switches:
    a. Provide three-way light switches adjacent to the doorways to control interior lights.

E. Lighting: In accordance with Section 26 50 00, Lighting.

1. Interior Lighting:
    a. Provide ceiling-mounted linear LED luminaires to provide a maintained average illuminance of not less than 30 footcandles on the floor of the building. Use an overall light loss factor of 0.85 for lighting calculations.
        1) Provide emergency battery ballasts in two of the luminaires.
2. Exterior Lighting:
    a. Provide wall-mounted full-cutoff LED luminaires to provide a maintained average illuminance of not less than 5 footcandles over an area within 6 feet of each of the doorways. Use an overall light loss factor of 0.85 for lighting calculations.
    b. Use the electronic programmable time switch to control the exterior lights.

2.06 FACTORY INSTALLATION

A. General:

1. Install equipment in accordance with NEMA ICS 2.3, NECA 402, submittals and manufacturers' written instructions and recommendations.
2. Secure equipment using anchor bolts of sufficient size and quantity adequate for specified conditions.
3. Install equipment plumb and in alignment with walls.
4. Tighten current-carrying bolted connections and enclosure support framing and panels to manufacturers' recommendations.

PART 3 EXECUTION

3.01 FIELD INSTALLATION

A. General:

1. Anchor the building to its foundation pad in accordance with building manufacturer's instructions.

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2. Re-tighten current-carrying bolted connections and enclosure support framing and panels to manufacturer's recommendations.

3.02 MANUFACTURER'S SERVICES

A. Furnish building manufacturer's representative in accordance with Section 01 43 33, Manufacturers Field Services, for the following services, for the minimum person-days listed below, travel time excluded:

1. 4 person-days for installation assistance and inspection of the installation.

END OF SECTION

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SECTION 26 05 04
BASIC ELECTRICAL MATERIALS AND METHODS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   a. A1011/A1011M, Standard Specification for Steel, Sheet, and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low Alloy and High-Strength Low Alloy Formability.
   b. E814, Method of Fire Tests of Through-Penetration Fire Stops.
2. Canadian Standards Association (CSA).
3. Institute of Electrical and Electronics Engineers, Inc. (IEEE): 18, Standard for Shunt Power Capacitors.
4. International Society of Automation (ISA): RP12.06.01, Wiring Practices for Hazardous (Classified) Locations Instrumentation–Part 1: Intrinsic Safety.
5. National Electrical Manufacturers Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
   b. C12.1, Code for Electricity Metering.
   c. C12.6, Phase-Shifting Devices Used in Metering, Marking and Arrangement of Terminals.
   d. ICS 2, Industrial Control and Systems: Controllers, Contactors, and Overload Relays Rated 600 Volts.
   e. ICS 5, Industrial Control and Systems: Control Circuit and Pilot Devices.
   f. KS 1, Enclosed and Miscellaneous Distribution Switches (600 Volts Maximum).
6. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
7. Underwriters Laboratories, Inc. (UL):
   a. 98, Standard for Enclosed and Dead-Front Switches.
   b. 248, Standard for Low Voltage Fuses.
   c. 486E, Standard for Equipment Wiring Terminals for use with Aluminum and/or Copper Conductors.
   d. 489, Standard for Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures.
   e. 508, Standard for Industrial Control Equipment.
   f. 810, Standard for Capacitors.
   g. 943, Standard for Ground-Fault Circuit-Interrupters.

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h. 1059, Standard for Terminal Blocks.
i. 1479, Fire Tests of Through-Penetration Fire Stops.

1.02 SUBMITTALS

A. Action Submittals:

1. Provide manufacturers' data for the following:
   a. Control devices.
   b. Control relays.
   c. Circuit breakers.
   d. Fused switches.
   e. Nonfused switches.
   f. Timers.
   g. Fuses.
   h. Magnetic contactors.
   i. Intrinsic safety barriers.
   j. Firestopping.
   k. Enclosures: Include enclosure data for products having enclosures.
   l. **[A: .]**
2. Seismic anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.

B. Informational Submittals: Seismic anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.

1.03 EXTRA MATERIALS

A. Furnish, tag, and box for shipment and storage the following spare parts and special tools:

1. Fuses, 0 Volt to 600 Volts: Six of each type and each current rating installed.
2. **[A: .]**

PART 2 PRODUCTS

2.01 MOLDED CASE CIRCUIT BREAKER THERMAL MAGNETIC, LOW VOLTAGE

A. General:

1. Type: Molded case.
2. Trip Ratings: 15 amps to 800 amps.
3. Voltage Ratings: 120, 240, 277, 480, and 600V ac.

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4. Suitable for mounting and operating in any position.
5. UL 489.

B. Operating Mechanism:

1. Overcenter, trip-free, toggle type handle.
2. Quick-make, quick-break action.
3. Locking provisions for padlocking breaker in OPEN position.
4. ON/OFF and TRIPPED indicating positions of operating handle.
5. Operating handle to assume a CENTER position when tripped.

C. Trip Mechanism:

1. Individual permanent thermal and magnetic trip elements in each pole.
2. Variable magnetic trip elements with a single continuous adjustment 3X to 10X for frames greater than 100 amps.
3. Two and three pole, common trip.
4. Automatically opens all poles when overcurrent occurs on one pole.
5. Test button on cover.
6. Calibrated for 40 degrees C ambient, unless shown otherwise.
7. Do not provide single-pole circuit breakers with handle ties where multi-pole circuit breakers are shown.

D. Short Circuit Interrupting Ratings:

1. Equal to, or greater than, available fault current or interrupting rating shown.
2. Not less than the following rms symmetrical currents for the indicated trip ratings:
   a. **Up to 100A, less than 250V ac: [D: [E: 10,000] [F:] amps].] [G: As shown.]**
   b. **Up to 100A, 250V ac to 600V ac: [H: [I: 14,000] [J:] amps].] [K: As shown.]**
   c. **Over 100A: [L: [M: 22,000] [N:] amps].] [O: As shown.]]**
3. **[P: Series Connected Ratings: Do not apply series connected short circuit ratings [Q: in NEC 700 Emergency Systems] [R: , except where specifically shown. Where shown, provide UL listed series ratings for the specific breaker/breaker and fuse/breaker combinations].]**

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E. Ground Fault Circuit Interrupter (GFCI): Where indicated, equip breaker as specified above with ground fault sensor and rated to trip on 5-mA ground fault within 0.025 second (UL 943, Class A sensitivity, for protection of personnel).

1. Ground fault sensor shall be rated same as circuit breaker.
2. Push-to-test button.

F. Equipment Ground Fault Interrupter (EGFI): Where indicated, equip breaker specified above with ground fault sensor and rated to trip on 30-mA ground fault (UL-listed for equipment ground fault protection).

G. Magnetic Only Type Breakers: Where shown; instantaneous trip adjustment which simultaneously sets magnetic trip level of each individual pole continuously through a 3X to 10X trip range.

H. Accessories: Shunt trip, auxiliary switches, handle lock ON devices, mechanical interlocks, key interlocks, unit mounting bases, double lugs as shown or otherwise required. Shunt trip operators shall be continuous duty rated or have coil-clearing contacts.

I. Connections:

1. Supply (line side) at either end.
2. Mechanical wire lugs, except crimp compression lugs where shown.
3. Lugs removable/replaceable for breaker frames greater than 100 amperes.
4. Suitable for 75 degrees C rated conductors without derating breaker or conductor ampacity.
5. Use bolted bus connections, except where bolt-on is not compatible with existing breaker provisions.

J. Enclosures for Independent Mounting:

1. See Article Enclosures.
2. Service Entrance Use: Breakers in required enclosure and required accessories shall be UL 489 listed.
3. Interlock: Enclosure and switch shall interlock to prevent opening cover with switch in the ON position. Provide bypass feature for use by qualified personnel.

2.02 FUSED SWITCH, INDIVIDUAL, LOW VOLTAGE

A. UL 98 listed for use and location of installation.

B. NEMA KS 1.

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C. Short Circuit Rating: 200,000 amps rms symmetrical with Class R, Class J, or Class L fuses installed.

D. Quick-make, quick-break, motor rated, load-break, heavy-duty (HD) type with external markings clearly indicating ON/OFF positions.

E. Connections:

1. Mechanical lugs, except crimp compression lugs where shown.
2. Lugs removable/replaceable.
3. Suitable for 75 degrees C rated conductors at NEC 75 degrees C ampacity.

F. Fuse Provisions:

1. 30-amp to 600-amp rated shall incorporate rejection feature to reject all fuses except Class R.
2. 601-amp rated and greater shall accept Class L fuses, unless otherwise shown.

G. Enclosures: See Article Enclosures.

H. Interlock: Enclosure and switch to prevent opening cover with switch in ON position. Provide bypass feature for use by qualified personnel.

2.03 NONFUSED SWITCH, INDIVIDUAL, LOW VOLTAGE

A. NEMA KS 1.

B. Quick-make, quick-break, motor rated, load-break, heavy-duty (HD) type with external markings clearly indicating ON/OFF positions.

C. Lugs: Suitable for use with 75 degrees C wire at NEC 75 degrees C ampacity.

D. Auxiliary Contact:

1. Operation: Make before power contacts make and break before power contacts break.
2. Contact Rating: 7,200VA make, 720VA break, at 600V, NEMA ICS 5 Designation A600.

E. Enclosures: See Article Enclosures.

F. Interlock: Enclosure and switch to prevent opening cover with switch in ON position. Provide bypass feature for use by qualified personnel.

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2.04 FUSE, 250-VOLT AND 600-VOLT

A. Power Distribution, General:

1. Current-limiting, with 200,000 ampere rms interrupting rating.
2. Provide to fit mountings specified with switches.
3. UL 248.

B. Power Distribution, Ampere Ratings 1 Amp to 600 Amps:

1. Class: RK-1.
2. Type: Dual element, with time delay.
3. Manufacturers and Products:
    a. Bussmann; Types LPS-RK (600 volts) and LPN-RK (250 volts).
    b. Littelfuse; Types LLS-RK (600 volts) and LLN-RK (250 volts).

C. Power Distribution, Ampere Ratings 601 Amps to 6,000 Amps:

1. Class: L.
2. Double O-rings and silver links.
3. Manufacturers and Products:
    a. Bussmann; Type KRP-C.
    b. Littelfuse, Inc.; Type KLPC.

D. Ferrule:

1. 600V or less, rated for applied voltage, small dimension.
2. Ampere Ratings: 1/10 amp to 30 amps.
3. Dual-element time-delay, time-delay, or nontime-delay as required.
4. Provide with blocks or holders as indicated and suitable for location and use.
5. Manufacturers:
    a. Bussmann.
    b. Littlefuse, Inc.

2.05 PUSHBUTTON, INDICATING LIGHT, AND SELECTOR SWITCH

A. Contact Rating: 7,200VA make, 720VA break, at 600V, NEMA ICS 5 Designation A600.

B. Selector Switch Operating Lever: Standard.

C. Indicating Light: Push-to-test. Push-to-test, LED, full voltage.

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D. Pushbutton Color:

1. ON or START: Black.
2. OFF or STOP: Red.

E. Pushbutton and selector switch lockable in OFF position where indicated.

F. Legend Plate:

1. Material: Aluminum.
2. Engraving: Enamel filled in high contrasting color.
3. Text Arrangement: 11-character/spaces on one line, 14-character/spaces on each of two lines, as required, indicating specific function.
4. Letter Height: 7/64 inch.

G. Manufacturers and Products:

1. Heavy-Duty, Oil-Tight Type:
   a. General Electric Co.; Type CR 104P.
   b. Square D Co.; Type T.
   c. Eaton/Cutler-Hammer; Type 10250T.
2. Heavy-Duty, Watertight, and Corrosion-Resistant Type:
   a. Square D Co.; Type SK.
   b. General Electric Co.; Type CR 104P.
   c. Eaton/Cutler-Hammer; Type E34.
   d. Crouse-Hinds; Type NCS.

2.06 TERMINAL BLOCK, 600 VOLTS

A. UL 486E and UL 1059.

B. Size components to allow insertion of necessary wire sizes.

C. Capable of termination of control circuits entering or leaving equipment, panels, or boxes.

D. Screw clamp compression, dead front barrier type, with current bar providing direct contact with wire between compression screw and yoke.

E. Yoke, current bar, and clamping screw of high strength and high conductivity metal.

F. Yoke shall guide all strands of wire into terminal.

G. Current bar shall ensure vibration-proof connection.

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H. Terminals:

1. Capable of wire connections without special preparation other than stripping.
2. Capable of jumper installation with no loss of terminal or rail space.
3. Individual, rail mounted.

I. Marking system, allowing use of preprinted or field-marked tags.

J. Manufacturers:

1. Weidmuller, Inc.
2. Ideal.
3. Electrovert USA Corp.

2.07 MAGNETIC CONTROL RELAY

A. Industrial control with field convertible contacts rated 10 amps continuous, 7,200VA make, 720VA break.

B. NEMA ICS 2, Designation: A300 (300 volts).

C. Latching Attachment: Mechanical latch, having unlatching coil and coil clearing contacts.

D. Manufacturers and Products:

1. Eaton/Cutler-Hammer; D26 Type M.
2. General Electric Co.; Type CR120A.
3. Square D; Type X.

2.08 TIME DELAY RELAY

A. Industrial relay with contacts rated 5 amps continuous, 3,600VA make, 360VA break.

B. NEMA ICS 2 Designation: B150 (150 volts).

C. Solid-state electronic, field convertible ON/OFF delay.

D. One normally open and one normally closed contact (minimum).

E. Repeat accuracy plus or minus 2 percent.

F. Timer adjustment from 1 second to 60 seconds, unless otherwise indicated on Drawings.

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G. Manufacturers and Products:

1. Square D Co.; Type XO.
2. Eaton/Cutler-Hammer; Type D26MR.
3. General Electric Co.; Type CR120.

2.09 RESET TIMER

A. Drive: Synchronous motor, solenoid-operated clutch.

B. Mounting: Semiflush panel.

C. Contacts: 10 amps, 120 volts.

D. Manufacturers and Products:

1. Eagle Signal Controls; Bulletin 125.
2. Automatic Timing and Controls; Bulletin 305.

2.10 ELAPSED TIME METER

A. Drive: Synchronous motor.

B. Range: 0 hour to 99,999.9 hours, nonreset type.

C. Mounting: Semiflush panel.

D. Manufacturers and Products:

1. General Electric Co.; Type 240, 2-1/2-inch Big Look.
2. Eagle Signal Controls; Bulletin 705.

2.11 MAGNETIC CONTACTOR

A. UL listed.

B. Electrically operated, electrically held.

C. Main Contacts:

1. Power driven in one direction with mechanical spring dropout.
2. Silver alloy with wiping action and arc quenchers.
3. Continuous-duty, rated as shown.
4. Poles: As shown.

D. Control: As shown.

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E. Auxiliary Contacts: One normally open and one normally closed, rated 7200VA make, 720VA break, at 600V, A600 per NEMA ICS 5.

F. Enclosures: See Article Enclosures.

G. Manufacturers and Products:

1. Eaton/Cutler-Hammer; Class A201.
2. General Electric Co.; CR 353.
3. Square D Co.; Class 8910.

2.12 PHASE MONITOR RELAY

A. Features:

1. Voltage and phase monitor relay shall drop out on low voltage, voltage unbalance, loss of phase, or phase reversal.
2. Contacts: Single-pole, double-throw, 10 amperes, 120/240V ac. Where additional contacts are shown or required, provide magnetic control relays.
3. Adjustable trip and time delay settings.
4. Transient Protection: 1,000V ac.
5. Mounting: Multipin plug-in socket base.

B. Manufacturer and Product: Automatic Timing and Controls; SLD Series.

2.13 MAGNETIC LIGHTING CONTACTOR

A. Comply with NEMA ICS 2; provide UL 508 listing.

B. Electrically operated by dual-acting, single coil mechanism.

C. Inherently interlocked and electrically held in CLOSED position.

D. Main Contacts:

1. Double-break, continuous-duty, rated 30 amperes, 600 volts, withstand rating of 22,000 amps rms symmetrical at 250 volts.
2. Marked for electric discharge lamps, tungsten, and general purpose loads.
3. Position not dependent on gravity, hooks, latches, or semipermanent magnets.
4. Capable of operating in any position.
5. Visual indication for each contact.

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E. One normally open and one normally closed auxiliary contact rated 10 amperes continuous, 7,200VA make, 720VA break with NEMA designation of A600 (600 volts).

F. 200 percent rated neutral terminal.

G. Clamp type, self-rising terminal plates for solderless connections.

H. Enclosures: See Article Enclosures.

I. Manufacturers and Products:

1. ASCO.
2. Eaton/Cutler-Hammer; Class A202.
3. General Electric Co.; Class 360 (electrically held).
4. Square D; Class 8903, **Type L (electrically held)] [D: Type LL (mechanically held)**.

2.14 SUPPORT AND FRAMING CHANNELS

A. Carbon Steel Framing Channel:

1. Material: Rolled, mild strip steel, 12-gauge minimum, ASTM A1011/ A1011M, Grade 33.
2. Finish: Hot-dip galvanized after fabrication.

B. Paint Coated Framing Channel: Carbon steel framing channel with electro-deposited rust inhibiting acrylic or epoxy paint.

C. PVC-Coated Framing Channel: Carbon steel framing channel with 40-mil polyvinyl chloride coating.

D. Stainless Steel Framing Channel: Rolled, Type 316 stainless steel, 12-gauge minimum.

E. Extruded Aluminum Framing Channel:

1. Material: Extruded from Type 6063-T6 aluminum alloy.
2. Fittings fabricated from Alloy 5052-H32.

F. Nonmetallic Framing Channel:

1. Material: Fire retardant, fiber reinforced vinyl ester resin.
2. Channel fitting of same material as channel.
3. Nuts and bolts of long glass fiber reinforced polyurethane.

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G. Manufacturers:

1. B-Line Systems, Inc.
2. Unistrut Corp.
3. Aickinstrut.

2.15 SWITCHBOARD MATTING

A. Provide matting having a breakdown of 20 kV minimum.

B. Manufacturer: U.S. Mat and Rubber Company.

2.16 FIRESTOPS

A. General:

1. Provide UL 1479 classified hourly fire rating equal to, or greater than, the assembly penetrated.
2. Prevent the passage of cold smoke, toxic fumes, and water before and after exposure to flame.
3. Sealants and accessories shall have fire-resistance ratings as established by testing identical assemblies in accordance with ASTM E814, by Underwriters Laboratories, Inc., or other testing and inspection agency acceptable to authorities having jurisdiction.

B. Comply with Section 07 84 00, Firestopping.

C. Firestop System:

1. Formulated for use in through-penetration firestopping around cables, conduit, pipes, and duct penetrations through fire-rated walls and floors.
2. Fill, Void, or Cavity Material: 3M Brand Fire Barrier Caulk CP25, Putty 303, Wrap/Strip FS195, Composite Sheet CS195 and Penetration Sealing Systems 7902 and 7904 Series.
3. Two-Part, Foamed-In-Place, Silicone Sealant: Dow Corning Corp. Fire Stop Foam, General Electric Co. Pensil 851.
4. Fire Stop Devices: See Section 26 05 33, Raceway and Boxes, for raceway and cable fittings.

2.17 ENCLOSURES

A. Finish: Sheet metal structural and enclosure parts shall be completely painted using an electrodeposition process so interior and exterior surfaces as well as bolted structural joints have a complete finish coat on and between them.

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B. Color: Manufacturer's standard color (gray) baked-on enamel, unless otherwise shown.

C. Barriers: Provide metal barriers within enclosures to separate wiring of different systems and voltage.

D. Enclosure Selections:

1. Except as shown otherwise, provide electrical enclosures according to the following table:

Enclosures			
Location	**Finish**	**Environment**	**NEMA 250 Type**
Indoor	Finished	Dry	1
Indoor	Unfinished	Dry	1
Indoor	Unfinished	Industrial Use	12
Indoor and Outdoor	Any	Wet	4
Indoor and Outdoor	Any	Denoted "WP"	3R
Indoor and Outdoor	Any	Wet and Corrosive	4X 304 Stainless Steel or FRP
Indoor and Outdoor	Any	Wet, Dust or Oil	12

PART 3 EXECUTION

3.01 GENERAL

A. Install equipment in accordance with manufacturer's recommendations.

3.02 PUSHBUTTON, INDICATING LIGHT, AND SELECTOR SWITCH

A. Install heavy-duty, oil-tight type in nonhazardous, indoor, dry locations, including motor control centers, control panels, and individual stations, unless otherwise shown.

B. Install heavy-duty, watertight and corrosion-resistant type in nonhazardous, outdoor, or normally wet areas, unless otherwise shown.

3.03 INDUSTRIAL CAPACITORS

A. Provide suitable hangers or mounting brackets for wall or ceiling mounting.

3.04 SUPPORT AND FRAMING CHANNEL

A. Install where required for mounting and supporting electrical equipment, raceway, and cable tray systems.

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B. Channel Type:

1. Interior, Wet or Dry (Noncorrosive) Locations:
   a. Aluminum Raceway: Extruded aluminum or carbon steel with neoprene material isolators.
   b. PVC-Coated Conduit: PVC coated.
   c. Steel Raceway and Other Systems Not Covered: Carbon steel or paint coated.
2. Interior, Corrosive (Wet or Dry) Locations:
   a. Aluminum Raceway: Extruded aluminum.
   b. PVC Conduit: Type 316 stainless steel or nonmetallic.
   c. PVC-Coated Steel Conduit and Other Systems Not Covered: Type 316 stainless steel, nonmetallic, or PVC-coated steel.
3. Outdoor, Noncorrosive Locations:
   a. Steel Raceway: Carbon steel or paint coated framing channel, except where mounted on aluminum handrail, then use aluminum framing channel.
   b. Aluminum Raceway and Other Systems Not Covered: Aluminum framing channel or carbon steel with neoprene material isolators.
4. Outdoor Corrosive Locations:
   a. PVC Conduit: Type 316 stainless steel or nonmetallic.
   b. Aluminum Raceway: Aluminum or carbon steel with neoprene material isolators.
   c. PVC-Coated Steel Conduit and Other Systems Not Covered: Type 316 stainless steel, nonmetallic, or PVC-coated steel.
5. Aluminum Railings: Devices mounted on aluminum railing shall use aluminum framing channel.

C. Paint cut ends prior to installation with the following:

1. Carbon Steel Channel: Zinc-rich primer.
2. Painted Channel: Rust-inhibiting epoxy or acrylic paint.
3. Nonmetallic Channel: Epoxy resin sealer.
4. PVC-Coated Channel: PVC patch.

3.05 SWITCHBOARD MATTING

A. Install 36-inch wide matting at switchgear, switchboards, motor control centers, and panelboards.

B. Matting shall run full length of all sides of equipment that have operator controls or afford access to devices.

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3.06 FIRESTOPS

A. Install in strict conformance with manufacturer’s instructions. Comply with installation requirements established by testing and inspecting agency.

B. Sealant: Install sealant including forming, packing, and other accessory materials, to fill openings around electrical services penetrating floors and walls, to provide firestops with fire-resistance ratings indicated for floor or wall assembly in which penetration occurs.

END OF SECTION

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SECTION 26 05 05
CONDUCTORS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Association of Edison Illuminating Companies (AEIC): CS 8, Specification for Extruded Dielectric Shielded Power Cables Rated 5 kV through 46 kV.
2. ASTM International (ASTM):
   a. A167, Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
   b. B3, Standard Specification for Soft or Annealed Copper Wire.
   c. B8, Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
   d. B496, Standard Specification for Compact Round Concentric-Lay-Stranded Copper Conductors.
3. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
   a. 48, Standard Test Procedures and Requirements for Alternating-Current Cable Terminations Used on Shielded Cables Having Laminated Insulation Rated 2.5 kV through 765 kV or Extruded Insulation Rated 2.5 kV Through 500 kV.
   b. 386, Standard for Separable Insulated Connector Systems for Power Distribution Systems Above 600V.
   c. 404, Standard for Extruded and Laminated Dielectric Shielded Cable Joints Rated 2500 V to 500000 V.
4. Insulated Cable Engineer's Association, Inc. (ICEA):
   a. S-58-679, Standard for Control Cable Conductor Identification.
   b. S-73-532, Standard for Control Thermocouple Extensions and Instrumentation Cables.
   c. T-29-520, Conducting Vertical Cable Tray Flame Tests with Theoretical Heat Input of 210,000 Btu/hour.
5. National Electrical Manufacturers' Association (NEMA):
   a. CC 1, Electric Power Connectors for Substations.
   b. WC 57, Standard for Control, Thermocouple Extension, and Instrumentation Cables.
   c. WC 70, Standard for Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy.
   d. WC 71, Standard for Nonshielded Cables Rated 2001-5000 Volts for Use in the Distribution of Electric Energy.
   e. WC 74, 5-46 kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy.

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6. National Fire Protection Association (NFPA):
    a. 70, National Electrical Code (NEC).
    b. 262, Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces.
7. Telecommunications Industry Association (TIA): TIA-568-C, Commercial Building Telecommunications Cabling Standard.
8. Underwriters Laboratories Inc. (UL):
    a. 13, Standard for Safety for Power-Limited Circuit Cables.
    b. 44, Standard for Safety for Thermoset-Insulated Wires and Cables.
    c. 62, Standard for Safety for Flexible Cord and Cables.
    d. 486A-486B, Standard for Safety for Wire Connectors.
    e. 486C, Standard for Safety for Splicing Wire Connectors.
    f. 510, Standard for Safety for Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape.
    g. 854, Standard for Safety for Service-Entrance Cables.
    h. 1072, Standard for Safety for Medium-Voltage Power Cables.
    i. 1277, Standard for Safety for Electrical Power and Control Tray Cables with Optional Optical-Fiber Members.
    j. 1569, Standard for Safety for Metal-Clad Cables.
    k. 1581, Standard for Safety for Reference Standard for Electrical Wires, Cables, and Flexible Cords.

1.02 SUBMITTALS

A. Action Submittals:

1. Product Data:
    a. Wire and cable.
    b. Wire and cable accessories.
    c. Cable fault detection system.
2. Manufactured Wire Systems:
    a. Product data.
    b. Rating information.
    c. Dimensional drawings.
    d. Special fittings.
3. Busway:
    a. Product data.
    b. Rating information.
    c. Dimensional drawings.
    d. Special fitting.
    e. Equipment interface information for equipment to be connected to busways.
4. Cable Pulling Calculations:
    a. Ensure submitted and reviewed before cable installation.

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b. Provide for the following cable installations:
   1) Medium voltage cable runs that cannot be hand pulled.
   2) Multiconductor 600-volt cable sizes larger than 2 AWG that cannot be hand pulled.
   3) Power and control conductor, and control and instrumentation cable installations in ductbanks.
   4) Feeder circuits; single conductors #4/0 and larger.

B. Informational Submittals:

1. Journeyman lineman or electrician splicing credentials.
2. Factory Test Report per AEIC CS 8, including AEIC qualification report for conductors above 600 volts.

1.03 QUALITY ASSURANCE

A. Authority Having Jurisdiction (AHJ):

1. Provide the Work in accordance with NFPA 70. Where required by the AHJ, material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ in order to provide a basis for approval under NEC.
2. Materials and equipment manufactured within the scope of standards published by Underwriters Laboratories Inc. shall conform to those standards and shall have an applied UL listing mark.

B. Terminations and Splices for Conductors above 600 Volts: Work shall be done by journeyman lineman with splicing credentials or electrician certified to use materials approved for cable splices and terminations.

PART 2 PRODUCTS

2.01 CONDUCTORS 600 VOLTS AND BELOW

A. Conform to applicable requirements of NEMA WC 70.

B. Conductor Type:

1. 120-Volt and 277-Volt Lighting, 10 AWG and Smaller: Solid copper.
2. 120-Volt Receptacle Circuits, 10 AWG and Smaller: Solid copper.
3. All Other Circuits: Stranded copper.

C. Insulation: Type THHN/THWN-2, except for sizes No. 6 and larger, with XHHW-2 insulation.

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D. Direct Burial and Aerial Conductors and Cables:

1. Type USE/RHH/RHW insulation, UL 854 listed, or Type RHW-2/USE-2.
2. Conform to physical and minimum thickness requirements of NEMA WC 70.

E. Flexible Cords and Cables:

1. Type SOW-A/50 with ethylene propylene rubber insulation in accordance with UL 62.
2. Conform to physical and minimum thickness requirements of NEMA WC 70.

2.02 CONDUCTORS ABOVE 600 VOLTS

A. EPR Insulated Cable:

1. Extrusion: Single-pass, triple-tandem, of conductor screen, insulation, and insulation screen.
2. Type: 25 kV, shielded, UL 1072, Type MV-105.
3. Conductors: Copper, except as where explicitly noted as aluminum, concentric lay Class B round stranded in accordance with ASTM B3, ASTM B8, and ASTM B496.
4. Conductor Screen: Extruded, semiconducting ethylene-propylene rubber in accordance with NEMA WC 71 and AEIC CS 8.
5. Insulation: 133 percent insulation level, ethylene-propylene rubber (EPR) containing no polyethylene, in accordance with NEMA WC 71, and AEIC CS 8.
6. Insulation Thickness: 260-mil, 25 kV, nominal.
7. Insulation Screen: Thermosetting, semiconducting ethylene-propylene rubber (EPR), extruded directly over insulation in accordance with NEMA WC 74 and AEIC CS 8.
8. Metallic Shield: Uncoated, 5-mil, copper shielding tape, helically applied with 12-1/2 percent minimum overlap.
9. Jacket: Extruded polyvinyl chloride (PVC) compound applied in accordance with NEMA WC 71 or NEMA WC 74.
10. Operating Temperature: 105 degrees C continuous normal operations, 130 degrees C emergency operating conditions, and 250 degrees C short-circuit conditions.
11. Manufacturers:
    a. General Cable.
    b. Southwire.
    c. Okonite.

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2.03 600-VOLT RATED CABLE

A. General:

1. Type TC, meeting requirements of UL 1277, including Vertical Tray Flame Test at 70,000 Btu per hour, and NFPA 70, Article 340, or UL 13 meeting requirements of NFPA 70, Article 725.
2. Permanently and legibly marked with manufacturer's name, maximum working voltage for which cable was tested, type of cable, and UL listing mark.
3. Suitable for installation in open air, in cable trays, or conduit.
4. Minimum Temperature Rating: 90 degrees C dry locations, 75 degrees C wet locations.
5. Overall Outer Jacket: PVC, flame-retardant, sunlight- and oil-resistant.

B. Type 1, Multiconductor Control Cable:

1. Conductors:
   a. 14 AWG, seven-strand copper.
   b. Insulation: 15-mil PVC with 4-mil nylon.
   c. UL 1581 listed as Type THHN/THWN rated VW-1.
   d. Conductor group bound with spiral wrap of barrier tape.
   e. Color Code: In accordance with ICEA S-58-679, Method 1, Table 2.
2. Cable: Passes the ICEA T-29-520, 210,000 Btu per hour Vertical Tray Flame Test.
3. Cable Sizes:

No. of Conductors	Max. Outside Diameter (Inches)	Jacket Thickness (Mils)
3	0.41	45
5	0.48	45
7	0.52	45
12	0.72	60
19	0.83	60
25	1.00	60
37	1.15	80

4. Manufacturers:
   a. Okonite Co.
   b. Southwire.

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C. Type 2, Multiconductor Power Cable:

1. General:
   a. Meet or exceed UL 1581 for cable tray use.
   b. Meet or exceed UL 1277 for direct burial and sunlight-resistance.
   c. Overall Jacket: PVC.
2. Conductors:
   a. Class B stranded, coated copper.
   b. Insulation: Chemically cross-linked ethylene-propylene or cross-linked polyethylene.
   c. UL rated VW-1 or listed Type XHHW-2.
   d. Color Code:
      1) Conductors, size 8 AWG and smaller, colored conductors, ICEA S-58-679, Method 1, Table 1.
      2) Conductors, size 6 AWG and larger, ICEA S-73-532, Method 4.
3. Cable shall pass ICEA T-29-520, 210,000 Btu per hour Vertical Tray Flame Test.
4. Cable Sizes:

Conductor Size	Minimum Ground Wire Size	No. of Current Carrying Conductors	Max. Outside Diameter (Inches)	Nominal Jacket Thickness (Mils)
12	12	2 3 4	0.42 0.45 0.49	45
10	10	2 3 4	0.54 0.58 0.63	60
8	10	3 4	0.66 0.75	60
6	8	3 4	0.74 0.88	60
4	6	3 4	0.88 1.04	60 80
2	6	3 4	1.01 1.16	80
1	6	3 4	1.10 1.25	80
1/0	6	3 4	1.22 1.35	80

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Conductor Size	Minimum Ground Wire Size	No. of Current Carrying Conductors	Max. Outside Diameter (Inches)	Nominal Jacket Thickness (Mils)
2/0	4	3 4	1.32 1.53	80
3/0	4	3 4	1.40 1.60	80
4/0	4	3 4	1.56 1.78	80 110

5. Manufacturers:
   a. Okonite Co.
   b. Southwire.

D. Type 3, 16 AWG, Twisted, Shielded Pair, Instrumentation Cable: Single pair, designed for noise rejection for process control, computer, or data log applications meeting NEMA WC 57 requirements.

1. Outer Jacket: 45-mil nominal thickness.
2. Individual Pair Shield: 1.35-mil, double-faced aluminum/synthetic polymer overlapped to provide 100 percent coverage.
3. Dimension: 0.31-inch nominal OD.
4. Conductors:
   a. Bare soft annealed copper, Class B, seven-strand concentric, meeting requirements of ASTM B8.
   b. 20 AWG, seven-strand tinned copper drain wire.
   c. Insulation: 15-mil nominal PVC.
   d. Jacket: 4-mil nominal nylon.
   e. Color Code: Pair conductors, black and red.
5. Manufacturers:
   a. Okonite Co.
   b. Alpha Wire Corp.
   c. Belden.

E. Type 4, 16 AWG, Twisted, Shielded Triad Instrumentation Cable: Single triad, designed for noise rejection for process control, computer, or data log applications meeting NEMA WC 57 requirements.

1. Outer Jacket: 45-mil nominal.
2. Individual Pair Shield: 1.35-mil, double-faced aluminum/synthetic polymer, overlapped to provide 100 percent coverage.
3. Dimension: 0.32-inch nominal OD.

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4. Conductors:
    a. Bare soft annealed copper, Class B, seven-strand concentric, meeting requirements of ASTM B8.
    b. 20 AWG, seven-strand, tinned copper drain wire.
    c. Insulation: 15-mil nominal PVC.
    d. Jacket: 4-mil nylon.
    e. Color Code: Triad conductors black, red, and blue.
5. Manufacturers:
    a. Okonite Co.
    b. Alpha Wire Corp.
    c. Belden.

F. Type 5, 18 AWG, Multitwisted Shielded Pairs, with a Common Overall Shield, Instrumentation Cable: Designed for use as instrumentation, process control, and computer cable, meeting NEMA WC 57 requirements.

1. Conductors:
    a. Bare soft annealed copper, Class B, seven-strand concentric, in accordance with ASTM B8.
    b. Tinned copper drain wires.
    c. Pair drain wire size AWG 20, group drain wire size AWG 18.
    d. Insulation: 15-mil PVC.
    e. Jacket: 4-mil nylon.
    f. Color Code: Pair conductors, black and red with red conductor numerically printed for group identification.
    g. Individual Pair Shield: 1.35-mil, double-faced aluminum/synthetic polymer.
2. Cable Shield: 2.35-mil, double-faced aluminum/synthetic polymer, overlapped for 100 percent coverage.
3. Cable Sizes:

Number of Pairs	Maximum Outside Diameter (Inches)	Nominal Jacket Thickness (Mils)
4	0.50	45
8	0.68	60
12	0.82	60
16	0.95	80
24	1.16	80
36	1.33	80
50	1.56	80

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4. Manufacturers:
    a. Alpha Wire.
    b. Belden.
    c. Okonite Co.

G. Type 6, 18 AWG, Multitwisted Pairs with Common Overall Shield Instrumentation Cable: Designed for use as instrumentation, process control, and computer cable meeting NEMA WC 57.

1. Conductors:
    a. Bare soft annealed copper, Class B, seven-strand concentric, in accordance with ASTM B8.
    b. Tinned copper drain wire size AWG 18.
    c. Insulation: 15-mil nominal PVC.
    d. Jacket: 4-mil nylon.
    e. Color Code: Pair conductors, black and red with red conductor numerically printed for group identification.
2. Cable Shield: 2.35-mil, double-faced aluminum/synthetic polymer, overlapped for 100 percent coverage.

Cable Sizes: Number of Pairs	**Maximum Outside Diameter (Inches)**	**Nominal Jacket Thickness (Mils)**
4	0.48	45
8	0.63	60
12	0.75	60
16	0.83	60
24	1.10	80
36	1.21	80
50	1.50	80

3. Manufacturers:
    a. Alpha Wire.
    b. Belden.
    c. Okonite Co.

H. Type 7, Multiconductor Metal-Clad (UL Type MC) Power Cable:

1. Meeting requirements of UL 44 and UL 1569.
2. Conductors:
    a. Class B stranded, coated copper.
    b. Insulation: 600-volt cross-linked polyethylene, UL Type XHHW or EPR.
    c. Grounding Conductors: Bare, stranded copper.

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3. Sheath:
   a. UL listed Type MC.
   b. Continuous welded, corrugated aluminum sheath.
   c. Suitable for use as grounding conductor.
4. Outer Jacket: PVC per UL 1569.
5. Cable shall pass ICEA T-29-520, 210,000 Btu per hour Vertical Tray Flame Test.
6. Cable Sizes:

Conductor Size	Minimum Ground Wire Size (AWG)	No. of Insulated Conductors	Max. Outside Diameter (Inches)	Jacket Thickness (Mils)
12 AWG	12 or 3x16	3 4	0.79 0.85	50
10 AWG	10 or 3x14	3 4	0.82 0.90	50
8 AWG	10 or 3x14	3 4	0.85 1.00	50
6 AWG	8 or 3x12	3 4	0.99 1.10	50
4 AWG	8 or 3x12	3 4	1.08 1.20	50
2 AWG	6 or 3x10	3 4	1.24 1.45	50
1 AWG	6 or 3x10	3 4	1.40 1.55	50
1/0 KCM	6 or 3x10	3 4	1.52 1.60	50
2/0 AWG	4 or 3x8	3 4	1.67 1.75	50
4/0 AWG	4 or 3x8	3 4	1.93 2.10	60
250 KCM	4 or 3x8	3 4	2.11 2.20	60
350 KCM	3 or 3x8	3 4	2.39 2.50	60
500 KCM	2 or 3x8	3 4	2.80 2.90	75

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7. Manufacturers and Products:
    a. General Cable, CCW Armored Power.
    b. Okonite Co.; Type CLX.
    c. Southwire Type MC.

2.04 300-VOLT RATED CABLE

A. General:

1. Type PLTC, meeting requirements of UL 13 and NFPA 70, Article 725.
2. Permanently and legibly marked with manufacturer's name, maximum working voltage for which cable was tested, type of cable, and UL listing mark.
3. Suitable for installation in open air, in cable trays, or conduit.
4. Minimum Temperature Rating: 105 degrees C.
5. Passes Vertical Tray Flame Test.
6. Outer Jacket: PVC, flame-retardant, sunlight- and oil-resistant.

B. Type 20, 16 AWG, Twisted, Shielded Pair Instrumentation Cable: Single pair, designed for noise rejection for process control, computer, or data log applications meeting NEMA WC 57.

1. Outer Jacket: 35-mil nominal.
2. Individual Pair Shield: 1.35-mil, double-faced aluminum/synthetic polymer, overlapped to provide 100 percent coverage.
3. Dimension: 0.26-inch nominal OD.
4. Conductors:
    a. Bare soft annealed copper, Class B, seven-strand concentric, ASTM B8.
    b. 20 AWG, seven-strand tinned copper drain wire.
    c. Insulation: 15-mil PVC.
    d. Color Code: Pair conductors black and white.
5. Manufacturers:
    a. Okonite Co.
    b. Alpha Wire Corp.

C. Type 21, 16 AWG, Twisted, Shielded Triad Instrumentation Cable: Single triad, designed for noise rejection for process control, computer, or data log applications meeting requirements of NEMA WC 57.

1. Outer Jacket: 35-mil nominal thickness.
2. Individual Pair Shield: 1.35-mil, double-faced aluminum/synthetic polymer, overlapped to provide 100 percent coverage.
3. Dimension: 0.28-inch nominal OD.

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4. Conductors:
    a. Bare soft annealed copper, Class B, seven-strand concentric, ASTM B8.
    b. 20 AWG, seven-strand tinned copper drain wire.
    c. Insulation: 15-mil PVC.
    d. Color Code: Triad conductors; black, red, and white.
5. Manufacturers:
    a. Okonite Co.
    b. Alpha Wire Corp.

D. Type 22, 18 AWG, Multitwisted, Shielded Pairs with a Common Overall Shield Instrumentation Cable: Designed for use as instrumentation, process control, and computer cable meeting NEMA WC 57.

1. Conductors:
    a. Bare soft annealed copper, Class B, seven-strand concentric, ASTM B8.
    b. Tinned copper drain wires.
    c. Pair drain wire size AWG 20, group drain wire size AWG 18.
    d. Insulation: 15-mil PVC.
    e. Color Code: Pair conductors black and white; white conductor numerically printed for group identification.
    f. Individual Pair Shield: 1.35-mil aluminum/mylar.
    g. Cable Shield: 2.35-mil, double-faced aluminum/synthetic polymer, overlapped for 100 percent coverage.
2. Cable Sizes:

Number of Pairs	Maximum Outside Diameter (Inches)	Nominal Jacket Thickness (Mils)
4	0.50	50
8	0.66	60
12	0.79	60
16	0.91	60
24	1.13	70
36	1.31	70
50	1.55	80

3. Manufacturers:
    a. Okonite Co.
    b. Alpha Wire Corp.
    c. Belden.

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E. Type 23, 18 AWG, Multitwisted Pairs with Common Overall Shield Instrumentation Cable: Designed for use as instrumentation, process control, and computer cable meeting NEMA WC 57.

1. Conductors:
   a. Bare soft annealed copper, Class B, seven-strand concentric, ASTM B8.
   b. Tinned copper.
   c. Group drain wire size AWG 20, minimum.
   d. Insulation: 15-mil PVC.
   e. Color Code: Pair conductors black and white; white conductor numerically printed for group identification.
   f. Cable Shield: 2.35-mil, double-faced aluminum/synthetic polymer, overlapped for 100 percent coverage.
2. Cable Sizes:

Number of Pairs	Maximum Outside Diameter (Inches)	Nominal Jacket Thickness (Mils)
4	0.48	50
8	0.63	60
12	0.73	60
16	0.77	60
24	0.96	70
36	1.09	70
50	1.45	50

3. Manufacturers:
   a. Okonite Co.
   b. Alpha Wire Corp.
   c. Belden.

F. Type 24, Twisted Pair Fire Alarm Cable **[A:, Shielded] [B:, Nonshielded]:** Power limited fire protective signaling circuit cable meeting requirements of NFPA 70, Article 760.

1. Cable: Pass NFPA 262, 70,000 Btu flame test and listed by **[C: California] [D:]** State Fire Marshall.
2. Outer Jacket: Red in color, identified along its entire length as fire protective signaling circuit cable.
3. Conductors:
   a. Solid, tinned, or bare copper **[E:, shielded, with stranded tinned copper drain wire]**.

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b. Insulation: 15-mil PVC.

c. [F: Shield: Aluminum/mylar spiral wound along entire length.]

4. Cable Sizes:

Wire Size	Maximum Outside Diameter (Inches)	Nominal Jacket Thickness (Inches)
12	0.36	0.042
14	0.32	0.042
16	0.26	0.037
18	0.23	0.037

5. Manufacturers:
   a. West Penn Wire.
   b. Coleman Cable, Inc.

2.05 SPECIAL CABLES

A. Type 30, Unshielded Twisted Pair (UTP) Telephone and Data Cable, 300V:

1. Category 6 UTP, UL listed, and third party verified to comply with TIA/EIA 568-C Category 6 requirements.
2. Suitable for high speed network applications including gigabit ethernet and video. Cable shall be interoperable with other standards compliant products and shall be backward compatible with Category 5 and Category 5e.
3. Provide four each individually twisted pair, 23 AWG conductors, with FEP insulation and blue PVC jacket.
4. NFPA 70 Plenum (CMP) rated; comply with flammability plenum requirements of NFPA 70 and NFPA 262.
5. Cable shall withstand a bend radius of 1-inch minimum at a temperature of minus 20 degrees C maximum without jacket or insulation cracking.
6. Manufacturer and Product: Belden; 7852A.

2.06 GROUNDING CONDUCTORS

A. Equipment: Stranded copper with green, Type USE/RHH/RHW-XLPE or THHN/THWN, insulation.

B. Direct Buried: Bare stranded copper.

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2.07 ACCESSORIES FOR CONDUCTORS 600 VOLTS AND BELOW

A. Tape:

1. General Purpose, Flame Retardant: 7-mil, vinyl plastic, Scotch Brand 33+, rated for 90 degrees C minimum, meeting requirements of UL 510.
2. Flame Retardant, Cold and Weather Resistant: 8.5-mil, vinyl plastic, Scotch Brand 88.
3. Arc and Fireproofing:
    a. 30-mil, elastomer.
    b. Manufacturers and Products:
        1) 3M; Scotch Brand 77, with Scotch Brand 69 glass cloth tapebinder.
        2) Plymouth; 53 Plyarc, with 77 Plyglas glass cloth tapebinder.

B. Identification Devices:

1. Sleeve:
    a. Permanent, PVC, yellow or white, with legible machine-printed black markings.
    b. Manufacturers and Products:
        1) Raychem; Type D-SCE or ZH-SCE.
        2) Brady, Type 3PS.
2. Heat Bond Marker:
    a. Transparent thermoplastic heat bonding film with acrylic pressure sensitive adhesive.
    b. Self-laminating protective shield over text.
    c. Machine printed black text.
    d. Manufacturer and Product: 3M Co.; Type SCS-HB.
3. Marker Plate: Nylon, with legible designations permanently hot stamped on plate.
4. Tie-On Cable Marker Tags:
    a. Chemical-resistant white tag.
    b. Size: 1/2 inch by 2 inches.
    c. Manufacturer and Product: Raychem; Type CM-SCE.
5. Grounding Conductor: Permanent green heat-shrink sleeve, 2-inch minimum.

C. Connectors and Terminations:

1. Nylon, Self-Insulated Crimp Connectors:
    a. Manufacturers and Products:
        1) Thomas & Betts; Sta-Kon.
        2) Burndy; Insulug.
        3) ILSCO.

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2. Nylon, Self-Insulated, Crimp Locking-Fork, Torque-Type Terminator:
    a. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.
    b. Seamless.
    c. Manufacturers and Products:
        1) Thomas & Betts; Sta-Kon.
        2) Burndy; Insulink.
        3) ILSCO; ILSCONS.
3. Self-Insulated, Freespring Wire Connector (Wire Nuts):
    a. UL 486C.
    b. Plated steel, square wire springs.
    c. Manufacturers and Products:
        1) Thomas & Betts.
        2) Ideal; Twister.
4. Self-Insulated, Set Screw Wire Connector:
    a. Two piece compression type with set screw in brass barrel.
    b. Insulated by insulator cap screwed over brass barrel.
    c. Manufacturers:
        1) 3M Co.
        2) Thomas & Betts.
        3) Marrette.

D. Cable Lugs:

1. In accordance with NEMA CC 1.
2. Rated 600 volts of same material as conductor metal.
3. Uninsulated Crimp Connectors and Terminators:
    a. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.
    b. Manufacturers and Products:
        1) Thomas & Betts; Color-Keyed.
        2) Burndy; Hydent.
        3) ILSCO.
4. Uninsulated, Bolted, Two-Way Connectors and Terminators:
    a. Manufacturers and Products:
        1) Thomas & Betts; Locktite.
        2) Burndy; Quiklug.
        3) ILSCO.

E. Cable Ties:

1. Nylon, adjustable, self-locking, and reusable.
2. Manufacturer and Product: Thomas & Betts; TY-RAP.

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F. Heat Shrinkable Insulation:

1. Thermally stabilized cross-linked polyolefin.
2. Single wall for insulation and strain relief.
3. Dual Wall, adhesive sealant lined, for sealing and corrosion resistance.
4. Manufacturers and Products:
    a. Thomas & Betts; SHRINK-KON.
    b. Raychem; RNF-100 and ES-2000.

2.08 ACCESSORIES FOR CONDUCTORS ABOVE 600 VOLTS

A. Molded Splice Kits:

1. Components necessary to provide insulation, metallic shielding and grounding systems, and overall jacket.
2. Capable of making splices with a current rating equal to, or greater than cable ampacity, conforming to IEEE 404.
3. Class 25 kV, with compression connector, EPDM molded semiconductive insert, peroxide-cured EPDM insulation, and EPDM molded semiconductive outer shield.
4. Premolded splice shall be rejacketed with a heat shrinkable adhesive-lined sleeve to provide a waterproof seal.
5. Manufacturers:
    a. 3M.
    b. Elastimold.
    c. Cooper Industries.

B. Heat Shrinkable Splice Kits:

1. Components necessary to provide insulation, metallic shielding and grounding systems, and overall jacket.
2. Capable of making splices with a current rating equal to, or greater than, cable ampacity, conforming to IEEE 404.
3. Class 25 kV, with compression connector, splice insulating and conducting sleeves, stress-relief materials, shielding braid and mesh, and abrasion-resistant heat shrinkable adhesive-lined rejacketing sleeve to provide a waterproof seal.
4. Manufacturers:
    a. Raychem.
    b. 3M Co.

C. Termination Kits:

1. Capable of terminating 25 kV, single-conductor, polymeric-insulated shielded cables plus a shield ground clamp.

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2. Capable of producing a termination with a current rating equal to, or greater than, cable ampacity meeting Class 1 requirements of IEEE 48.
3. Capable of accommodating cable shielding or construction without need for special adapters or accessories.
4. Manufacturers:
    a. Raychem.
    b. 3M Co.

D. Elbow Connector Systems:

1. Molded, peroxide-cured, EPDM-insulated, Class 25 kV, 125 kV BIL, 200A, 15,000A rms nonload-break elbows as shown, having copper current-carrying parts in accordance with IEEE 386.
2. Protective Caps: Class 25 kV, 125 kV BIL, 200 amperes, with molded EPDM insulated body.
3. Insulated Standoff Bushings: Class 25 kV, 125 kV BIL, 200 amperes, complete with EPDM rubber body, stainless steel eyebolt with brass pressure foot, and stainless steel base bracket.
4. Bushing Inserts: Class 25 kV, 125 kV BIL, 200A, nonload-break with EPDM rubber body and all-copper, current-carrying parts.
5. Junctions: Class : 25 kV, 125 kV two-way, four-way, or as otherwise shown on the Drawings 200A, load-break, having EPDM rubber body mounted on adjustable bracket.
6. Mounting Plates: Four-way, or as shown on the Drawings, ASTM A167 stainless steel, complete with universal mounting brackets, grounding lugs and two parking stands.
7. Manufacturers:
    a. Cooper Industries.
    b. Elastimold.

E. Cable Lugs:

1. In accordance with NEMA CC1.
2. Rated 25 kV of same material as conductor metal.
3. Manufacturers and Products, Uninsulated Compression Connectors and Terminators:
    a. Burndy; Hydent.
    b. Thomas & Betts; Color-Keyed.
    c. ILSCO.
4. Manufacturers and Products, Uninsulated, Bolted, Two-Way Connectors and Terminators:
    a. Thomas & Betts; Locktite.
    b. ILSCO.

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2.09 PULLING COMPOUND

A. Nontoxic, noncorrosive, noncombustible, nonflammable, water-based lubricant; UL listed.

B. Suitable for rubber, neoprene, PVC, polyethylene, hypalon, CPE, and lead-covered wire and cable.

C. Approved for intended use by cable manufacturer.

D. Suitable for zinc-coated steel, aluminum, PVC, bituminized fiber, and fiberglass raceways.

E. Manufacturers:

1. Ideal Co.
2. Polywater, Inc.
3. Cable Grip Co.

2.10 WARNING TAPE

A. As specified in Section 26 05 33, Raceway and Boxes.

2.11 SOURCE QUALITY CONTROL

A. Conductors 600 Volts and Below: Test in accordance with UL 44 and UL 854.

B. Conductors Above 600 Volts: Test in accordance with NEMA WC 71 and AEIC CS 8 partial discharge level test for EPR insulated cable.

PART 3 EXECUTION

3.01 GENERAL

A. Conductor installation shall be in accordance with manufacturer’s recommendations.

B. Conductor and cable sizing shown is based on copper conductors, unless noted otherwise.

C. Do not exceed cable manufacturer’s recommendations for maximum pulling tensions and minimum bending radii.

D. Terminate conductors and cables, unless otherwise indicated.

E. Tighten screws and terminal bolts in accordance with UL 486A-486B for copper conductors [and aluminum conductors].

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F. Cable Lugs: Provide with correct number of holes, bolt size, and center-to-center spacing as required by equipment terminals.

G. Bundling: Where single conductors and cables in manholes, handholes, vaults, cable trays, and other indicated locations are not wrapped together by some other means, bundle conductors from each conduit throughout their exposed length with cable ties placed at intervals not exceeding 12 inches on center.

H. Ream, remove burrs, and clear interior of installed conduit before pulling wires or cables.

I. Concrete-Encased Raceway Installation: Prior to installation of conductors, pull through each raceway a mandrel approximately 1/4 inch smaller than raceway inside diameter.

J. Cable Tray Installation:

1. Install wire and cable parallel and straight in tray.
2. Bundle, in groups, wire and cable of same voltage having a common routing and destination; use cable ties, at maximum intervals of 8 feet.
3. Clamp cable bundles prior to making end termination connections.
4. Separate cables of different voltage rating in same cable tray with barriers.
5. Fasten wires, cables, and bundles to tray with nylon cable straps at the following maximum intervals:
   a. Horizontal Runs: 20 feet.
   b. Vertical Runs: 5 feet.

3.02 POWER CONDUCTOR COLOR CODING

A. Conductors 600 Volts and Below:

1. 6 AWG and Larger: Apply general purpose, flame retardant tape at each end, and at accessible locations wrapped at least six full overlapping turns, covering area 1-1/2 inches to 2 inches wide.
2. 8 AWG and Smaller: Provide colored conductors.
3. Colors:

System	Conductor	Color
All Systems	Equipment Grounding	Green
240/120 Volts, Single-Phase, Three-Wire	Grounded Neutral One Hot Leg Other Hot Leg	White Black Red

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System	Conductor	Color
208Y/120 Volts, Three-Phase, Four-Wire	Grounded Neutral Phase A Phase B Phase C	White Black Red Blue
240/120 Volts, Three-Phase, Four-Wire, Delta, Center Tap, Ground on Single-Phase	Grounded Neutral Phase A High (wild) Leg Phase C	White Black Orange Blue
480Y/277 Volts, Three-Phase, Four-Wire	Grounded Neutral Phase A Phase B Phase C	White Brown Orange Yellow
Note: Phase A, B, C implies direction of positive phase rotation.		

4. Tracer: Outer covering of white with identifiable colored strip, other than green, in accordance with NFPA 70.

B. Conductors Above 600 Volts:

1. Apply general purpose, yellow flame retardant tape at each end, and at accessible locations wrapped at least six full overlapping turns, covering area 1 inch to 1-1/2 inches.
2. Colors:
   a. Grounded Neutral: White.
   b. Phase A: One stripe.
   c. Phase B: Two stripes.
   d. Phase C: Three stripes.

3.03 CIRCUIT IDENTIFICATION

A. Identify power, instrumentation, and control conductor circuits at each termination, and in accessible locations such as manholes, handholes, panels, switchboards, motor control centers, pull boxes, and terminal boxes.

B. Circuits Appearing in Circuit Schedules: Identify using circuit schedule designations.

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C. Circuits Not Appearing in Circuit Schedules:

1. Assign circuit name based on device or equipment at load end of circuit.
2. Where this would result in same name being assigned to more than one circuit, add number or letter to each otherwise identical circuit name to make it unique.

D. Method:

1. Conductors 3 AWG and Smaller: Identify with sleeves or heat bond markers.
2. Cables and Conductors 2 AWG and Larger:
   a. Identify with marker plates or tie-on cable marker tags.
   b. Attach with nylon tie cord.
3. Taped-on markers or tags relying on adhesives not permitted.

3.04 CONDUCTORS 600 VOLTS AND BELOW

A. Install 10 AWG or 12 AWG conductors for branch circuit power wiring in lighting and receptacle circuits.

B. Do not splice incoming service conductors and branch power distribution conductors 6 AWG and larger, unless specifically indicated or approved by Engineer.

C. Connections and Terminations:

1. Install wire nuts only on solid conductors. Wire nuts are not allowed on stranded conductors.
2. Install nylon self-insulated crimp connectors and terminators for instrumentation and control, circuit conductors.
3. Install self-insulated, set screw wire connectors for two-way connection of power circuit conductors 12 AWG and smaller.
4. Install uninsulated crimp connectors and terminators for instrumentation, control, and power circuit conductors 4 AWG through 2/0 AWG.
5. Install uninsulated, bolted, two-way connectors and terminators for power circuit conductors 3/0 AWG and larger.
6. Install uninsulated terminators bolted together on motor circuit conductors 10 AWG and larger.
7. Place no more than one conductor in any single-barrel pressure connection.
8. Install crimp connectors with tools approved by connector manufacturer.
9. Install terminals and connectors acceptable for type of material used.

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10. Where aluminum conductors are provided, apply oxide-inhibiting compound at joints and terminations.
11. Compression Lugs:
    a. Attach with a tool specifically designed for purpose. Tool shall provide complete, controlled crimp and shall not release until crimp is complete.
    b.
    c. Install connectors designed for aluminum conductors utilizing compression barrel termination of conductor and terminating in dual rated lug.
    d. Do not use plier type crimpers.

D. Do not use soldered mechanical joints.

E. Splices and Terminations:

1. Insulate uninsulated connections.
2. Indoors: Use general purpose, flame retardant tape or single wall heat shrink.
3. Outdoors, Dry Locations: Use flame retardant, cold- and weather-resistant tape or single wall heat shrink.
4. Below Grade and Wet or Damp Locations: Use dual wall heat shrink.

F. Cap spare conductors with UL listed end caps.

G. Cabinets, Panels, and Motor Control Centers:

1. Remove surplus wire, bridle and secure.
2. Where conductors pass through openings or over edges in sheet metal, remove burrs, chamfer edges, and install bushings and protective strips of insulating material to protect the conductors.

H. Control and Instrumentation Wiring:

1. Where terminals provided will accept such lugs, terminate control and instrumentation wiring, except solid thermocouple leads, with insulated, locking-fork compression lugs.
2. Terminate with methods consistent with terminals provided, and in accordance with terminal manufacturer’s instructions.
3. Locate splices in readily accessible cabinets or junction boxes using terminal strips.
4. Where connections of cables installed under this section are to be made under Section 40 90 00, Instrumentation and Control for Process Systems, leave pigtails of adequate length for bundled connections.
5. Cable Protection:
    a. Under Infinite Access Floors: May install without bundling.

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b. All Other Areas: Install individual wires, pairs, or triads in flex conduit under floor or grouped into bundles at least 1/2 inch in diameter.
c. Maintain integrity of shielding of instrumentation cables.
d. Ensure grounds do not occur because of damage to jacket over shield.

I. Extra Conductor Length: For conductors to be connected by others, install minimum 6 feet of extra conductor in freestanding panels and minimum 2 feet in other assemblies.

3.05 CONDUCTORS ABOVE 600 VOLTS

A. Do not splice unless specifically indicated or approved by Engineer.

B. Make joints and terminations with splice and termination kits, in accordance with kit manufacturer's instructions.

C. Install splices or terminations as continuous operation in accessible locations under clean, dry conditions.

D. Single Conductor Cable Terminations: Provide heat shrinkable stress control and outer nontracking insulation tubings, high relative permittivity stress relief mastic for insulation shield cutback treatment, and a heat-activated sealant for environmental sealing plus a ground braid and clamp.

E. Install terminals or connectors acceptable for type of conductor material used.

F. Provide outdoor rain skirts for: riser pole and outdoor switchgear terminations.

G. Provide shield termination and grounding for terminations.

H. Provide necessary mounting hardware, covers, and connectors.

I. Where elbow connectors are specified, install in accordance with manufacturer's instructions.

J. Connections and Terminations:

1. Install uninsulated crimp connectors and terminators for power circuit conductors 4 AWG and larger.
2. Install uninsulated, bolted, two-way connectors for motor circuit conductors No. 12 and larger.
3. Insulate bus connections with heat shrinking tubing, tape, and sheets.
4. Make bus connections removable and reusable in accordance with manufacturer's instructions.

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K. Where aluminum conductors are used, apply oxide-inhibiting compound at joints and terminations. Use compounds compatible with cable insulation and with components used for splicing and terminating.

L. Give 2 working days notice to Engineer prior to making splices or terminations.

3.06 CONDUCTOR ARC AND FIREPROOFING

A. Install arc and fireproofing tape on 600-volt single conductors and cables, except those rated Type TC throughout entire exposed length in manholes, handholes, vaults, cable trays, and other indicated locations.

B. Install arc and fireproofing tape on 25 kV cables throughout entire exposed lenght in manholes, handholes, vaults, cable trays, and other indicated locations.

C. Wrap conductors of same circuit entering from separate conduit together as single cable.

D. Follow tape manufacturer's installation instructions.

E. Secure tape at intervals of 5 feet with bands of tapebinder. Each band to consist of a minimum of two wraps directly over each other.

3.07 UNDERGROUND DIRECT BURIAL CABLE

A. Install in trench as specified in **[A: Section 31 23 23.15, Trench Backfill] [B:].**

B. Warning Tape: Install approximately 12 inches above cable, aligned parallel to, and within 12 inches of centerline of the run.

END OF SECTION

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SECTION 26 05 26
GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Institute of Electrical and Electronics Engineers (IEEE): C2, National Electrical Safety Code (NESC).
2. National Fire Protection Association (NFPA): 70, National Electrical Code. (NEC).

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Product data for the following:
      1) Exothermic weld connectors.
      2) Mechanical connectors.
      3) Compression connectors.
      4) Specialty tools.

1.03 QUALITY ASSURANCE

A. Authority Having Jurisdiction (AHJ):

1. Provide the Work in accordance with NFPA 70, National Electrical Code (NEC). Where required by the AHJ, material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ in order to provide a basis for approval under NEC.
2. Materials and equipment manufactured within the scope of standards published by Underwriters Laboratories, Inc. shall conform to those standards and shall have an applied UL listing mark.

PART 2 PRODUCTS

2.01 GROUND CONDUCTORS

A. As specified in Section 26 05 05, Conductors.

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2.02 CONNECTORS

A. Exothermic Weld Type:

1. Outdoor Weld: Suitable for exposure to elements or direct burial.
2. Indoor Weld: Utilize low-smoke, low-emission process.
3. Manufacturers:
    a. Erico Products, Inc. Cadweld and Cadweld Exolon.
    b. Thermoweld.

B. Compression Type:

1. Compress-deforming type; wrought copper extrusion material.
2. Single indentation for conductors 6 AWG and smaller.
3. Double indentation with extended barrel for conductors 4 AWG and larger.
4. Barrels prefilled with oxide-inhibiting and antiseizing compound and sealed.
5. Manufacturers:
    a. Burndy Corp.; Hyground Irreversible Compression.
    b. Thomas and Betts Co.
    c. ILSCO.

C. Mechanical Type: Split-bolt, saddle, or cone screw type; copper alloy material.

1. Manufacturers:
    a. Burndy Corp.
    b. Thomas and Betts Co.

PART 3 EXECUTION

3.01 GENERAL

A. Grounding shall be in compliance with NFPA 70 and IEEE C2.

B. Ground electrical service neutral at service entrance equipment with grounding electrode conductor to grounding electrode system.

C. Ground each separately derived system neutral with common grounding electrode conductor to grounding electrode system.

D. Bond together all grounding electrodes that are present at each building or structure served to form one common grounding electrode system.

E. Bond together system neutrals, service equipment enclosures, exposed noncurrent-carrying metal parts of electrical equipment, metal raceways,

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ground conductor in raceways and cables, receptacle ground connections, and metal piping systems.

F. Shielded Power Cables: Ground shields at each splice or termination in accordance with recommendations of splice or termination manufacturer.

G. Shielded Instrumentation Cables:

1. Ground shield to ground bus at power supply for analog signal.
2. Expose shield minimum 1 inch at termination to field instrument and apply heat shrink tube.
3. Do not ground instrumentation cable shield at more than one point.

3.02 WIRE CONNECTIONS

A. Ground Conductors: Install in conduit containing power conductors and control circuits above 50 volts.

B. Nonmetallic Raceways and Flexible Tubing: Install equipment grounding conductor connected at both ends to noncurrent-carrying grounding bus.

C. Connect ground conductors to raceway grounding bushings.

D. Extend and connect ground conductors to ground bus in all equipment containing a ground bus.

E. Connect enclosure of equipment containing ground bus to that bus.

F. Bolt connections to equipment ground bus.

G. Bond grounding conductors to metallic enclosures at each end, and to intermediate metallic enclosures.

H. Junction Boxes: Furnish materials and connect to equipment grounding system with grounding clips mounted directly on box, or with 3/8-inch machine screws.

I. Metallic Equipment Enclosures: Use furnished ground lug; if none furnished, tap equipment housing and install solderless terminal connected to box with machine screw. For circuits greater than 20 amps use minimum 5/16-inch diameter bolt.

3.03 MOTOR GROUNDING

A. Extend equipment ground bus via grounding conductor installed in motor feeder raceway; connect to motor frame.

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B. Nonmetallic Raceways and Flexible Tubing: Install an equipment grounding conductor connected at both ends to noncurrent-carrying grounding bus.

C. Motors Less Than 10 hp: Use furnished ground lug in motor connection box; if none furnished, provide compression, spade-type terminal connected to conduit box mounting screw.

D. Motors 10 hp and Above: Use furnished ground lug in motor connection box; if none furnished, tap motor frame or equipment housing; furnish compression, one-hole, lug type terminal connected with minimum 5/16-inch brass threaded stud with bolt and washer.

E. Circuits 20 Amps or Above: Tap motor frame or equipment housing; install solderless terminal with minimum 5/16-inch diameter bolt.

3.04 CONNECTIONS

A. General:

1. Abovegrade Connections: Install exothermic weld, mechanical, or compression-type connectors; or brazing.
2. Belowgrade Connections: Install exothermic weld or compression type connectors.
3. Remove paint, dirt, or other surface coverings at connection points to allow good metal-to-metal contact.
4. Notify Engineer prior to backfilling ground connections.

B. Exothermic Weld Type:

1. Wire brush or file contact point to bare metal surface.
2. Use welding cartridges and molds in accordance with manufacturer’s recommendations.
3. Avoid using badly worn molds.
4. Mold to be completely filled with metal when making welds.
5. After completed welds have cooled, brush slag from weld area and thoroughly clean joint.

C. Compression Type:

1. Install in accordance with connector manufacturer’s recommendations.
2. Install connectors of proper size for grounding conductors and ground rods specified.
3. Install using connector manufacturer’s compression tool having proper sized dies and operate per manufacturer’s instructions.

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D. Mechanical Type:

1. Apply homogeneous blend of colloidal copper and rust and corrosion inhibitor before making connection.
2. Install in accordance with connector manufacturer's recommendations.
3. Do not conceal mechanical connections.

3.05 METAL STRUCTURE GROUNDING

A. Bond metal sheathing and exposed metal vertical structural elements to grounding system.

B. Bond electrical equipment supported by metal platforms to the platforms.

C. Provide electrical contact between metal frames and railings supporting pushbutton stations, receptacles, and instrument cabinets, and raceways carrying circuits to these devices.

3.06 MANHOLE AND HANDHOLE GROUNDING

A. Install one ground rod inside each manhole and handhole larger than 24-inch by 24-inch inside dimensions.

B. Ground Rod Floor Protrusion: 4 inches to 6 inches above floor.

C. Make connections of grounding conductors fully visible and accessible.

D. Connect all noncurrent-carrying metal parts, and any metallic raceway grounding bushings to ground rod with 6 AWG copper conductor.

3.07 TRANSFORMER GROUNDING

A. Bond neutrals of transformers within buildings to system ground network, and to any additional indicated grounding electrodes.

B. Bond neutrals of substation transformer secondary connections system grounding network.

3.08 LIGHTNING PROTECTION SYSTEMS

A. Bond lightning protection system ground terminals to building or structure grounding electrode system.

3.09 SURGE PROTECTION EQUIPMENT GROUNDING

A. Connect surge arrestor ground terminals to equipment ground bus.

END OF SECTION

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SECTION 26 05 33
RACEWAY AND BOXES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Association of State Highway and Transportation Officials (AASHTO): HB, Standard Specifications for Highway Bridges.
2. ASTM International (ASTM):
   a. A123/123M, Standard Specification for Zinc (Hot-Dipped Galvanized) Coatings on Iron and Steel Products.
   b. A167, Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
   c. A240/A240M, Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
   d. C857, Standard Practice for Minimum Structural Design Loading for Underground Precast Concrete Utility Structures.
   e. D149, Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies.
3. Telecommunications Industry Association (TIA): 569B, Commercial Building Standard for Telecommunications Pathways and Spaces.
4. National Electrical Contractor's Association, Inc. (NECA): Installation standards.
5. National Electrical Manufacturers Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
   b. C80.1, Electrical Rigid Steel Conduit (ERSC).
   c. C80.3, Steel Electrical Metallic Tubing (EMT).
   d. C80.5, Electrical Rigid Aluminum Conduit (ERAC).
   e. C80.6, Electrical Intermediate Metal Conduit (EIMC).
   f. RN 1, Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit.
   g. TC 2, Electrical Polyvinyl Chloride (PVC) Conduit.
   h. TC 3, Polyvinyl Chloride (PVC) Fittings for Use with Rigid PVC Conduit and Tubing.
   i. TC 6, Polyvinyl Chloride (PVC) Plastic Utilities Duct for Underground Installation.
   j. TC 14, Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.
   k. VE 1, Metallic Cable Tray Systems.

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6. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
7. Underwriters Laboratories Inc. (UL):
    a. 1, Standard for Safety for Flexible Metal Conduit.
    b. 5, Standard for Safety for Surface Metal Raceways and Fittings.
    c. 6, Standard for Safety for Electrical Rigid Metal Conduit – Steel.
    d. 6A, Standard for Safety for Electrical Rigid Metal Conduit – Aluminum, Red Brass and Stainless.
    e. 360, Standard for Safety for Liquid-Tight Flexible Steel Conduit.
    f. 514B, Standard for Safety for Conduit, Tubing, and Cable Fittings.
    g. 651, Standard for Safety for Schedule 40 and 80 Rigid PVC Conduit and Fittings.
    h. 651A, Standard for Safety for Type EB and A Rigid PVC Conduit and HDPE Conduit.
    i. 797, Standard for Safety for Electrical Metallic Tubing – Steel.
    j. 870, Standard for Safety for Wireways, Auxiliary Gutters, and Associated Fittings.
    k. 1660, Standard for Safety for Liquid-Tight Flexible Nonmetallic Conduit.
    l. 1684, Standard for Safety for Reinforced Thermosetting Resin Conduit (RTRC) and Fittings.
    m. 2024, Standard for Safety for Optical Fiber and Communication Cable Raceway.

1.02 SUBMITTALS

A. Action Submittals:

1. Precast Manholes and Handholes:
    a. Dimensional drawings and descriptive literature.
    b. Traffic loading calculations.
    c. Accessory information.
2. Precast Equipment Pads:
    a. Dimensional drawings and descriptive literature.
3. Telecommunications Pathway Cable Tray:
    a. Dimensional drawings, calculations, and descriptive information.
    b. NEMA load/span designation and how it was selected.
    c. Support span length and pounds-per-foot actual and future cable loading at locations, with safety factor used.
    d. Location and magnitude of maximum simple beam deflection of tray for loading specified.
    e. Layout drawings and list of accessories being provided.
4. Cable Tray Systems:
    a. Dimensional drawings, calculations, and descriptive information.
    b. NEMA load/span designation and how it was selected.

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c. Support span length and pounds-per-foot actual and future cable loading at locations, with safety factor used.
d. Location and magnitude of maximum simple beam deflection of tray for loading specified.
e. Layout drawings and list of accessories being provided.

5. Seismic anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.
6. Conduit Layout:
   a. Provide drawings for conduit installations underground and concealed conduits including, but not limited to ductbanks, under floor slabs, concealed in floor slabs, and concealed in walls.
   b. Electronic CAD; scale not greater than 1 inch equals 20 feet.

B. Informational Submittals:

1. Seismic anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Component and attachment testing seismic certificate of compliance as required by Section 01 45 33, Special Inspection **[A:, Observation,]** and Testing.
3. Manufacturer's certification of training for PVC-coated rigid galvanized steel conduit installer.

1.03 QUALITY ASSURANCE

A. Authority Having Jurisdiction (AHJ):

1. Provide the Work in accordance with NFPA 70, National Electrical Code (NEC). Where required by the AHJ, material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ in order to provide a basis for approval under NEC.
2. Materials and equipment manufactured within scope of standards published by Underwriters Laboratories, Inc. shall conform to those standards and shall have an applied UL listing mark.

B. PVC-Coated, Rigid Galvanized Steel Conduit Installer: Certified by conduit manufacturer as having received minimum 2 hours of training on installation procedures.

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PART 2 PRODUCTS

2.01 CONDUIT AND TUBING

A. Rigid Galvanized Steel Conduit (RGS):

1. Meet requirements of NEMA C80.1 and UL 6.
2. Material: Hot-dip galvanized with chromated protective layer.

B. Intermediate Metal Conduit (IMC):

1. Meet requirements of NEMA C80.6 and UL 1242.
2. Material: Hot-dip galvanized with chromated and lacquered protective layer.

C. Electric Metallic Tubing (EMT):

1. Meet requirements of NEMA C80.3 and UL 797.
2. Material: Hot-dip galvanized with chromated and lacquered protective layer.

D. Rigid Aluminum Conduit:

1. Meet requirements of NEMA C80.5 and UL 6A.
2. Material: Type 6063, copper-free aluminum alloy.

E. PVC Schedule 40 Conduit:

1. Meet requirements of NEMA TC 2 and UL 651.
2. UL listed for concrete encasement, underground direct burial, concealed or direct sunlight exposure, and 90 degrees C insulated conductors.

F. PVC Schedule 80 Conduit:

1. Meet requirements of NEMA TC 2 and UL 651.
2. UL listed for concrete encasement, underground direct burial, concealed or direct sunlight exposure, and 90 degrees C insulated conductors.

G. Fiberglass Conduit:

1. Meet requirements of NEMA TC 14 and UL 1684.
2. Winding: Single circuit with angle as close to 54.75 as possible.
3. Resin System: Epoxy based using and anhydride curing agent.
4. Use carbon black as ultraviolet inhibitor.
5. Toxicity: Conduit shall not contain compounds that can release halogens in more than trace amounts when burning.
6. Dielectric Strength: Exceed 400 volts per mil when tested in accordance with ASTM D149.

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7. Jointing System: Two-part epoxy adhesive supplied by conduit manufacturer.
8. Manufacturers:
    a. Champion Fiberglass.
    b. Osburn Associates.
    c. FRE Composites, Inc.

H. PVC-Coated Rigid Galvanized Steel Conduit:

1. Meet requirements of NEMA RN 1 **[A: and ETL]**.
2. Material:
    a. Meet requirements of NEMA C80.1 and UL 6.
    b. Exterior Finish: PVC coating, 40-mil nominal thickness; bond to metal shall have tensile strength greater than PVC.
    c. Interior finish: Urethane coating, 2-mil nominal thickness.
3. Threads: Hot-dipped galvanized and factory coated with urethane.
4. Bendable without damage to interior or exterior coating.

I. Flexible Metal, Liquid-Tight Conduit:

1. UL 360 listed for 105 degrees C insulated conductors.
2. Material: Galvanized steel with extruded PVC jacket.

J. Innerduct:

1. Resistant to spread of fire, per requirements of UL 2024.
2. Smooth or corrugated HDPE.
3. Textile Manufacturer: Maxcell.

2.02 FITTINGS

A. Rigid Galvanized Steel and Intermediate Metal Conduit:

1. General:
    a. Meet requirements of UL 514B.
    b. Type: Threaded, galvanized. Set screw and threadless compression fittings not permitted.
2. Bushing:
    a. Material: Malleable iron with integral insulated throat, rated for 150 degrees C.
    b. Manufacturers and Products:
        1) Appleton; Series BU-I.
        2) O-Z/Gedney; Type HB.
3. Grounding Bushing:
    a. Material: Malleable iron with integral insulated throat rated for 150 degrees C, with solderless lugs.

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b. Manufacturers and Products:
    1) Appleton; Series GIB.
    2) O-Z/Gedney; Type HBLG.

4. Conduit Hub:
    a. Material: Malleable iron with insulated throat with bonding screw.
    b. UL listed for use in wet locations.
    c. Manufacturers and Products:
        1) Appleton, Series HUB-B.
        2) O-Z/Gedney; Series CH.
        3) Meyers; ST Series.
5. Conduit Bodies:
    a. Sized as required by NFPA 70.
    b. Manufacturers and Products (For Normal Conditions):
        1) Appleton; Form 35 threaded unilets.
        2) Crouse-Hinds; Form 7 or Form 8 threaded condulets.
        3) Killark; Series O electrolets.
        4) Thomas & Betts; Form 7 or Form 8.
    c. Manufacturers (For Hazardous Locations):
        1) Appleton.
        2) Crouse-Hinds.
        3) Killark.
6. Couplings: As supplied by conduit manufacturer.
7. Unions:
    a. Concrete tight, hot-dip galvanized malleable iron.
    b. Manufacturers and Products:
        1) Appleton; Series SCC bolt-on coupling or Series EC three-piece union.
        2) O-Z/Gedney; Type SSP split coupling or Type 4 Series, three-piece coupling.
8. Conduit Sealing Fitting:
    a. Manufacturers and Products:
        1) Appleton; Type EYF, EYM, or ESU.
        2) Crouse-Hinds; Type EYS or EZS.
        3) Killark; Type EY or Type EYS.
9. Drain Seal:
    a. Manufacturers and Products:
        1) Appleton; Type EYD.
        2) Crouse-Hinds; Type EYD or Type EZD.
10. Drain/Breather Fitting:
    a. Manufacturers and Products:
        1) Appleton; Type ECDB.
        2) Crouse-Hinds; ECD.

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11. Expansion Fitting:
    a. Manufacturers and Products:
        1) Deflection/Expansion Movement:
            a) Appleton; Type DF.
            b) Crouse-Hinds; Type XD.
        2) Expansion Movement Only:
            a) Appleton; Type XJ.
            b) Crouse-Hinds; Type XJ.
            c) Thomas & Betts; XJG-TP.
12. Cable Sealing Fitting:
    a. To form watertight nonslip cord or cable connection to conduit.
    b. For Conductors with OD of 1/2 inch or Less: Neoprene bushing at connector entry.
    c. Manufacturers and Products:
        1) Appleton; CG-S.
        2) Crouse-Hinds; CGBS.

B. Electric Metallic Tubing:

1. Meet requirements of UL 514B.
2. Type: Steel body and locknuts with steel or malleable iron compression nuts. Set screw and drive-on fittings not permitted.
3. Electro zinc-plated inside and out.
4. Raintight.
5. Coupling Manufacturers and Products:
    a. Appleton; Type 95T.
    b. Crouse-Hinds.
    c. Thomas & Betts.
6. Connector Manufacturers and Products:
    a. Appleton; Type ETP.
    b. Crouse-Hinds.
    c. Thomas & Betts.

C. Rigid Aluminum Conduit:

1. General:
    a. Meet requirements of UL 514B.
    b. Type: Threaded, copper-free. Set screw fittings not permitted.
2. Insulated Bushing:
    a. Material: Cast aluminum, with integral insulated throat, rated for 150 degrees C.
    b. Manufacturer and Product: O-Z/Gedney; Type AB.
3. Grounding Bushing:
    a. Material: Cast aluminum with integral insulated throat, rated for 150 degrees, with solderless lugs.
    b. Manufacturer and Product: O-Z/Gedney; Type ABLG.

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4. Conduit Hub:
    a. Material: Cast aluminum, with insulated throat.
    b. UL listed for use in wet locations.
    c. Manufacturers and Products:
        1) O-Z/Gedney; Type CHA.
        2) Thomas & Betts; Series 370AL.
        3) Meyers; Series SA.
5. Conduit Bodies:
    a. Manufacturers and Products (For Normal Conditions):
        1) Appleton; Form 85 threaded unilets.
        2) Crouse-Hinds; Mark 9 or Form 7-SA threaded condulets.
        3) Killark; Series O electrolets.
    b. Manufacturers (For Hazardous Locations):
        1) Appleton.
        2) Crouse-Hinds.
        3) Killark.
6. Couplings: As supplied by conduit manufacturer.
7. Conduit Sealing Fitting:
    a. Manufacturers and Products:
        1) Appleton; Type EYF-AL or EYM-AL.
        2) Crouse-Hinds; Type EYS-SA or EZS-SA.
        3) Killark; Type EY or Type EYS.
8. Drain Seal:
    a. Manufacturers and Products:
        1) Appleton; Type EYDM-A.
        2) Crouse-Hinds; Type EYD-SA or Type EZD-SA.
9. Drain/Breather Fitting:
    a. Manufacturers and Products:
        1) Appleton; Type ECDB.
        2) Crouse-Hinds; ECD.
10. Expansion Fitting:
    a. Manufacturers and Products:
        1) Deflection/Expansion Movement: Steel City; Type DF-A.
        2) Expansion Movement Only: Steel City; Type AF-A.
11. Cable Sealing Fittings:
    a. To form watertight nonslip cord or cable connection to conduit.
    b. Bushing: Neoprene at connector entry.
    c. Manufacturer and Product: Appleton; CG-S.

D. PVC Conduit and Tubing:

1. Meet requirements of NEMA TC 3.
2. Type: PVC, slip-on.

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E. Fiberglass Conduit:

1. Manufactured by same process as conduit.
2. Supplied by conduit manufacturer.

F. PVC-Coated Rigid Galvanized Steel Conduit:

1. Meet requirements of UL 514B.
2. Fittings: Rigid galvanized steel type, PVC coated by conduit manufacturer.
3. Conduit Bodies: Cast metal hot-dipped galvanized or urethane finish. Cover shall be of same material as conduit body. PVC coated by conduit manufacturer.
4. Finish: 40-mil PVC exterior, 2-mil urethane interior.
5. Overlapping pressure-sealing sleeves.
6. Conduit Hangers, Attachments, and Accessories: PVC-coated.
7. Manufacturers:
   a. Robroy Industries.
   b. Ocal.
8. Expansion Fitting:
   a. Manufacturer and Product: Ocal; OCAL-BLUE XJG.

G. Flexible Metal, Liquid-Tight Conduit:

1. Metal insulated throat connectors with integral nylon or plastic bushing rated for 105 degrees C.
2. Insulated throat and sealing O-rings.
3. Manufacturers and Products:
   a. Thomas & Betts; Series 5331.
   b. O-Z/Gedney; Series 4Q.

H. Flexible Metal, Nonliquid-Tight Conduit:

1. Meet requirements of UL 514B.
2. Body: Galvanized steel or malleable iron.
3. Throat: Nylon insulated.
4. 1-1/4-Inch Conduit and Smaller: One screw body.
5. 1-1/2-Inch Conduit and Larger: Two screw body.
6. Manufacturer and Product: Appleton; Series 7400.

I. Watertight Entrance Seal Device:

1. New Construction:
   a. Material: Oversized sleeve, malleable iron body with sealing ring, pressure ring, grommet seal, and pressure clamp.
   b. Manufacturer and Product: O-Z/Gedney; Type FSK or Type WSK, as required.

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2. Cored-Hole Application:
    a. Material: Assembled dual pressure disks, neoprene sealing ring, and membrane clamp.
    b. Manufacturer and Product: O-Z/Gedney; Series CSM.

2.03 OUTLET AND DEVICE BOXES

A. Sheet Steel: One-piece drawn type, zinc-plated or cadmium-plated.

B. Cast Metal:

1. Box: Malleable iron or cast ferrous metal.
2. Cover: Gasketed, weatherproof, malleable iron, or cast ferrous metal, with stainless steel screws.
3. Hubs: Threaded.
4. Lugs: Cast Mounting.
5. Manufacturers and Products, Nonhazardous Locations:
    a. Crouse-Hinds; Type FS or Type FD.
    b. Appleton; Type FS or Type FD.
    c. Killark.
6. Manufacturers and Products, Hazardous Locations:
    a. Crouse-Hinds; Type GUA or Type EAJ.
    b. Appleton; Type GR.

C. Cast Aluminum:

1. Material:
    a. Box: Cast, copper-free aluminum.
    b. Cover: Gasketed, weatherproof, cast copper-free aluminum with stainless steel screws.
2. Hubs: Threaded.
3. Lugs: Cast mounting.
4. Manufacturers and Products, Nonhazardous Locations:
    a. Crouse-Hinds; Type FS-SA or Type FD-SA.
    b. Appleton; Type FS or Type FD.
    c. Killark.
5. Manufacturers and Products, Hazardous Locations:
    a. Crouse-Hinds; Type GUA-SA.
    b. Appleton; Type GR.

D. PVC-Coated Cast Metal:

1. Type: One-piece.
2. Material: Malleable iron, cast ferrous metal, or cast aluminum.
3. Coating:
    a. Exterior Surfaces: 40-mil PVC.
    b. Interior Surfaces: 2-mil urethane.

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4. Manufacturers:
    a. Robroy Industries.
    b. Ocal.

E. Nonmetallic:

1. Box: PVC.
2. Cover: PVC, weatherproof, with stainless steel screws.
3. Manufacturer and Product: Carlon; Type FS or Type FD, with Type E98 or Type E96 covers.

2.04 JUNCTION AND PULL BOXES

A. Outlet Box Used as Junction or Pull Box: As specified under Article Outlet and Device Boxes.

B. Conduit Bodies Used as Junction Boxes: As specified under Article Fittings.

C. Large Sheet Steel Box:

1. NEMA 250, Type 1.
2. Box: Code-gauge, galvanized steel.
3. Cover: Full access, screw type.
4. Machine Screws: Corrosion-resistant.

D. Large Cast Metal Box:

1. NEMA 250, Type **4**.
2. Box: Cast malleable iron, or ferrous metal, **[H: electrogalvanized finished,]** with drilled and tapped conduit entrances and exterior mounting lugs.
3. Cover: Hinged with clamps or screws.
4. Gasket: Neoprene.
5. Hardware and Machine Screws: ASTM A167, Type 316 stainless steel.
6. Manufacturers and Products, Surface Mounted Nonhinged Type:
    a. Crouse-Hinds; Series W.
    b. O-Z/Gedney; Series Y.
7. Manufacturer and Product, Surface Mounted, Hinged Type: O-Z/Gedney; Series YW.
8. Manufacturers and Products, Recessed Type:
    a. Crouse-Hinds; Type WJBF.
    b. O-Z/Gedney; Series YR.

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E. Large Cast Aluminum Box:

1. NEMA 250 Type 4.
2. Box: Cast copper-free aluminum, with drilled and tapped conduit entrances and exterior mounting lugs.
3. Cover: Nonhinged.
4. Gasket: Neoprene.
5. Hardware and Machine Screws: ASTM A167, Type 316 stainless steel.
6. Manufacturers and Products, Surface Mounted Type:
    a. Crouse-Hinds; Series W-SA.
    b. O-Z/Gedney; Series YS-A, YL-A.
    c. Killark.

F. Large Stainless Steel Box:

1. NEMA 250 Type 4X.
2. Box: 14-gauge, ASTM A240/A240M, Type 304 stainless steel, with white enamel painted interior mounting panel.
3. Cover: Hinged withclamps.
4. Hardware and Machine Screws: ASTM A167, Type **304 316** stainless steel.
5. Manufacturers:
    a. Hoffman Engineering Co.
    b. Robroy Industries.
    c. Wiegman.

G. Large Steel Box:

1. NEMA 250 Type 1.
2. Box: With white enamel painted interior and gray exterior. Provide gray finish as approved byCH2M.
3. Cover: Hinged with clamps.
4. Hardware and Machine Screws: ASTM A167, Type 316 stainless steel.
5. Manufacturers:
    a. Hoffman Engineering Co.
    b. Robroy Industries.
    c. Wiegman.

H. Large Nonmetallic Box:

1. NEMA 250 Type 4X.
2. Box: High-impact, fiberglass-reinforced polyester or engineered thermoplastic, with stability to high heat.
3. Cover: Hinged with clamps.
4. Hardware and Machine Screws: ASTM A167, Type 316 stainless steel.
5. Conduit hubs and mounting lugs.

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6. Manufacturers and Products:
    a. Crouse-Hinds; Type NJB.
    b. Carlon; Series N, C, or H.
    c. Robroy Industries.

2.05 TELEPHONE TERMINAL CABINET

A. Material: Code-gauge galvanized steel box with hinged doors and 3/4-inch fire-resistant plywood backboard, meeting requirements of telephone service provider.

B. Finish: Provide **[A: gray] [B:]** finish as approved by **[C: Owner] [D: Engineer]**.

C. Minimum Size: 18 inches high by 18 inches wide by 6 inches deep.

2.06 TELEPHONE AND DATA OUTLET

A. Provide outlet boxes and cover plates meeting requirements of TIA 569B.

2.07 TERMINAL JUNCTION BOX

A. Cover: Hinged, unless otherwise shown.

B. Interior Finish: Paint with white enamel or lacquer.

C. Terminal Blocks:

1. Separate connection point for each conductor entering or leaving box.
2. Spare Terminal Points: 50 percent, minimum.

2.08 SURFACE METAL RACEWAY

A. General:

1. Meet requirements of UL 5.
2. Material: Two-piece, code-gauge steel.
3. Finish: Factory applied rust inhibiting primer and gray semi-gloss finish suitable for field painting.
4. Configuration: Single, 1-17/32-inch by 2-3/4-inch section, unless otherwise indicated.

B. Fittings and Accessories:

1. Wire clips at 30 inches on center.
2. Couplings, cover clips, supporting clips, ground clamps, and elbows as required; to comply with manufacturer’s recommendations.

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C. Outlets:

1. Provide bracket or device covers as required to support wiring devices indicated.
2. Wiring Devices and Device Plates: In accordance with Section 26 27 26, Wiring Devices.
3. Manufacturers:
   a. The Wiremold Co.
   b. Walker.

2.09 METAL WIREWAYS

A. Meet requirements of UL 870.

B. Type: Steel-enclosed, lay-in type.

C. Cover: Hinged with friction latch.

D. Rating: Indoor.

E. Finish: Manufacturer’s standard, gray.

F. Hardware: Plated to prevent corrosion; screws installed toward the inside protected by spring nuts or otherwise guarded to prevent wire insulation damage.

G. Knockouts: Without knockouts, unless otherwise indicated.

H. Manufacturers:

1. Circle AW.
2. Hoffman.
3. Square D.

2.10 CABLE TRAYS

A. Meet requirements of NEMA VE 1.

B. Type: Ladder, of welded construction.

C. Material: Copper-free aluminum alloy 6063-T6 finish.

D. Dimensions: NEMA standard sizes. Fittings with 24-inch bending radius.

E. Cover: Solid, minimum: 0.40-inch-thick aluminum.

F. Barrier Strip: Vertical, solid type, with horizontal fittings and strip clamps.

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G. Fittings of same material as cross-sectional tray area and hardware of same material as cable tray.

H. Tray Grounding: Conform to NFPA 70 and NEMA VE 1.

I. Provide next higher NEMA VE 1 class designation than required for support of designed span length.

J. Design Loads: Use working load adequate for actual cable installed plus 30 percent additional weight allowance for future cables plus 200-pound concentrated static load applied between side rails at midspan, with safety factor of 1.5 in accordance with NEMA VE 1, Table 3-1.

K. Expansion Joints:

1. Indoor installation: NEMA VE 1 for 25 degrees F maximum temperature variation.
2. Outdoor installation: NEMA VE1 for 100 degrees F maximum temperature variation.

L. Furnish cable tray with no sharp edges, burrs, or weld projections.

M. Warning Signs: 1-1/2-inch high black lettering on yellow background with legend, “WARNING, NOT TO BE USED AS WALKWAY, LADDER, OR SUPPORT FOR LADDERS OR PERSONNEL.”

N. Manufacturers:

1. B-Line Systems, Inc.
2. Square-D.
3. P. W. Industries.
4. T. J. Cope, Inc.

2.11 TELECOMMUNICATIONS PATHWAY CABLE TRAY

A. Meet requirements of NEMA VE 1.

B. Type: Ladder, of welded construction.

C. Material: Copper-free aluminum alloy 6063-T6 finish.

D. Dimensions: Unless otherwise indicated, 18 inches wide, with 4-inch NEMA nominal inside fill depth and fittings with 24-inch bending radius.

E. Fittings of same material as cross-sectional tray area and hardware of same material as cable tray. Include dropouts for cable exits from bottom of tray as required.

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F. Tray Grounding: Conform to NFPA 70 and NEMA VE 1.

G. Warning Signs: 1-1/2-inch (40-mm) high black lettering on yellow background with legend, “WARNING! NOT TO BE USED AS WALKWAY, LADDER, OR SUPPORT FOR LADDERS OR PERSONNEL.”

H. Design Loads: 15 pounds per linear foot with less than 1-inch deflection, and maximum 50 pounds per linear foot, when supported on 12-foot centers.

I. Expansion Joints: NEMA VE 1 for 50 degrees F maximum temperature variation, with bonding jumper.

J. Furnish cable tray with no sharp edges, burrs, or weld projections.

K. Manufacturers:

1. B-Line Systems, Inc.
2. Square-D.
3. P.W. Industries.

2.12 PRECAST MANHOLES AND HANDHOLES

A. Nominal size: 4 feet by 4 feet by 4 feet, except where noted on the drawings.

B. Concrete Strength: Minimum, 3,000 psi compressive, in 28 days.

C. Loading: AASHTO, H-20 in accordance with ASTM C857.

D. Access: Provide cast concrete 6-inch or 12-inch risers and access hole adapters between top of manhole and finished grade at required elevations.

E. Drainage:

1. Slope floors toward drain points, leaving no pockets or other nondraining areas.
2. Provide drainage outlet or sump at low point of floor constructed with a heavy, cast iron, slotted or perforated hinged cover, and a minimum 4-inch outlet and outlet pipe.

F. Raceway Entrances:

1. Provide on all four sides.
2. Provide knockout panels or precast individual raceway openings.
3. At entrances where raceways are to be installed by others, provide minimum 12-inch-high by 24-inch-wide knockout panels for future raceway installation.

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G. Embedded Pulling Iron:

1. Material: 3/4-inch-diameter stock, fastened to overall steel reinforcement before concrete is placed.
2. Location:
    a. Wall: Opposite each raceway entrance and knockout panel for future raceway entrance.
    b. Floor: Centered below manhole or handhole cover.

H. Cable Racks:

1. Arms and Insulators: Adjustable, of sufficient number to accommodate cables for each raceway entering or leaving manhole, including spares.
2. Wall Attachment:
    a. Adjustable inserts in concrete walls. Bolts or embedded studs not permitted.
    b. Insert Spacing: Maximum 3 feet on center for inside perimeter of manhole.
    c. Arrange in order that spare raceway ends are clear for future cable installation.

I. Manhole Frames and Covers:

1. Material: Machined cast iron.
2. Diameter: 36-1/2 inch.
3. Cover Type: Indented, solid top design, with two drop handles each.
4. Cover Loading: AASHTO H-20.
5. Cover Designation: Cast, on upper side, in integral letters, minimum 2 inches in height, appropriate titles:
    a. Above 600 Volts: ELECTRIC HV.
    b. 600 Volts and Below: ELECTRIC LV.
    c. COMMUNICATIONS.

J. Handhole Frames and Covers:

1. Material: Steel, hot-dipped galvanized.
2. Cover Type: Solid, hinged, torsion spring, of nonskid design.
3. Cover Loading: AASHTO H-20.
4. Cover Designation: Burn by welder, on upper side in integral letters, minimum 2 inches in height, appropriate titles:
    a. 600 Volts and Below: ELECTRIC LV.
    b. COMMUNICATIONS.

K. Hardware: Steel, hot-dip galvanized.

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L. Manufacturers:

a. Oldcastle Precast.
b. ABC Concrete.
c. Albuquerque Vault Company.
d. Four Corners Pre-Cast.

2.13 PRECAST EQUIPMENT PADS

A. As shown on the drawings.

B. Concrete Strength: Minimum, 3,000 psi compressive, in 28 days.

C. Raceway Entrances: Provide precast raceway opening window.

D. Manufacturers:

a. Oldcastle Precast.
b. ABC Concrete.
c. Albuquerque Vault Company.
d. Four Corners Pre-Cast.

2.14 ACCESSORIES

A. Duct Bank Spacers:

1. Modular Type:
   a. Nonmetallic, interlocking, for multiple conduit sizes.
   b. Suitable for all types of conduit.
   c. Manufacturers:
      1) Underground Device, Inc.
      2) Carlon.
2. Template Type:
   a. Nonmetallic, custom made one-piece spacers.
   b. Suitable for all types of conduit.
   c. Material: HDPE or polypropylene, 1/2-inch minimum thickness.
   d. Conduit openings cut 1 inch larger than conduit outside diameter.
   e. Additional openings for stake-down, rebar, and concrete flow through as required.
   f. Manufacturer and Product: SP Products; Quik Duct.

B. Identification Devices:

1. Raceway Tags:
   a. Material: Permanent, **[A: nonferrous metal] [B: nylon] [C: polyethylene]**.
   b. Shape: Round.

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c. Raceway Designation: Pressure stamped, embossed, or engraved.
d. Tags relying on adhesives or taped-on markers not permitted.

2. Warning Tape:
   a. Material: Polyethylene, 4-mil gauge with detectable strip.
   b. Color: Red.
   c. Width: Minimum **6** inches.
   d. Designation: Warning on tape that electric circuit is located below tape.
   e. Identifying Letters: Minimum 1-inch-high permanent black lettering imprinted continuously over entire length.
   f. Manufacturers and Products:
      1) Panduit; Type HTDU.
      2) Reef Industries; Terra Tape.

3. Buried Raceway Marker:
   a. Material: Sheet bronze, consisting of double-ended arrows, straight for straight runs and bent at locations where runs change direction.
   b. Designation: Engrave to depth of 3/32 inch; ELECTRIC CABLES, in letters 1/4-inch high.
   c. Minimum Dimension: 1/4 inch thick, 10 inches long, and 3/4 inch wide.

C. Heat Shrinkable Tubing:

1. Material: Heat-shrinkable, cross-linked polyolefin.
2. Semi-flexible with meltable adhesive inner liner.
3. Color: Black.
4. Manufacturers:
   a. Raychem.
   b. 3M.

D. Wraparound Duct Band:

1. Material: Heat-shrinkable, cross-linked polyolefin, precoated with hot-melt adhesive.
2. Width: 50 mm minimum.
3. Manufacturer and Product: Raychem; Type TWDB.

PART 3 EXECUTION

3.01 GENERAL

A. Conduit and tubing sizes shown are based on use of copper conductors. Reference Section 26 05 05, Conductors, concerning conduit sizing for aluminum conductors.

B. Comply with NECA Installation Standards.

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C. Crushed or deformed raceways not permitted.

D. Maintain raceway entirely free of obstructions and moisture.

E. Immediately after installation, plug or cap raceway ends with watertight and dust-tight seals until time for pulling in conductors.

F. Aluminum Conduit: Do not install in direct contact with concrete. Install in PVC sleeve or cored hole through concrete walls and slabs.

G. Sealing Fittings: Provide drain seal in vertical raceways where condensate may collect above sealing fitting.

H. Avoid moisture traps where possible. When unavoidable in exposed conduit runs, provide junction box and drain fitting at conduit low point.

I. Group raceways installed in same area.

J. Proximity to Heated Piping: Install raceways minimum 12 inches from parallel runs.

K. Follow structural surface contours when installing exposed raceways. Avoid obstruction of passageways.

L. Run exposed raceways parallel or perpendicular to walls, structural members, or intersections of vertical planes.

M. Block Walls: Do not install raceways in same horizontal course or vertical cell with reinforcing steel.

N. Install watertight fittings in outdoor, underground, or wet locations.

O. Paint threads and cut ends, before assembly of fittings, galvanized conduit, PVC-coated galvanized conduit, or IMC installed in exposed or damp locations with zinc-rich paint or liquid galvanizing compound.

P. Metal conduit shall be reamed, burrs removed, and cleaned before installation of conductors, wires, or cables.

Q. Do not install raceways in concrete equipment pads, foundations, or beams without Engineer approval.

R. Horizontal raceways installed under floor slabs shall lie completely under slab, with no part embedded within slab.

S. Install concealed, embedded, and buried raceways so that they emerge at right angles to surface and have no curved portion exposed.

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T. Install conduits for fiber optic cables, telephone cables, and Category 6 data cables in strict conformance with the requirements of TIA 569B.

3.02 INSTALLATION IN CAST-IN-PLACE STRUCTURAL CONCRETE

A. Minimum Cover: 2 inches, including fittings.

B. Conduit placement shall not require changes in reinforcing steel location or configuration.

C. Provide nonmetallic support during placement of concrete to ensure raceways remain in position.

D. Conduit larger than 1 inch shall not be embedded in concrete slabs, walls, foundations, columns, or beams unless shown on the Drawings or approved by CH2M.

E. Slabs and Walls (Requires CH2M Approval):

1. Trade size of conduit not to exceed one-fourth of slab or wall thickness.
2. Install within middle two-fourths of slab or wall.
3. Separate conduit less than 2-inch trade size by a minimum ten times conduit trade size, center-to-center, unless otherwise shown.
4. Separate conduit 2-inch and greater trade size by a minimum eight times conduit trade size, center-to-center, unless otherwise shown.
5. Cross conduit at an angle greater than 45 degrees, with minimum separation of 1 inch.
6. Separate conduit by a minimum six times the outside dimension of expansion/deflection fittings at expansion joints.
7. Conduit shall not be installed below the maximum water surface elevation in walls of water holding structures.

F. Columns and Beams (Requires Engineer Approval):

1. Trade size of conduit not to exceed one-fourth of beam thickness.
2. Conduit cross-sectional area not to exceed 4 percent of beam or column cross section.

3.03 CONDUIT APPLICATION

A. Diameter:

1. Underground and embedded in concrete: Minimum 1 inch.
2. Above ground: Minimum 3/4 inch, except for lighting whips, which may be 3/8 inch.

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B. Exterior, Exposed:

1. Rigid galvanized steel.
2. Rigid aluminum.
3. PVC-coated rigid galvanized steel.

C. Interior, Exposed:

1. Rigid galvanized steel.
2. Rigid aluminum Intermediate metal.
3. PVC-coated rigid galvanized steel.

D. Interior, Concealed (Not Embedded in Concrete):

1. Rigid galvanized steel.
2. Rigid aluminum.
3. Electric metallic tubing.
4. PVC-coated rigid galvanized steel.

E. Aboveground, Embedded in Concrete Walls, Ceilings, or Floors: PVC Schedule 40.

F. Direct Earth Burial:

1. PVC Schedule 40 for ac circuits, PVC-Coated Rigid Galvanized Steel for dc circuits.
2. PVC Schedule 80.
3. PVC-coated rigid galvanized steel.

G. Under Slabs-On-Grade:

1. PVC Schedule 40 for ac circuits, PVC-Coated Rigid Galvanized Steel for dc circuits.
2. PVC Schedule 80.
3. PVC-coated rigid galvanized steel.

H. Transition from Underground or Concrete Embedded to Exposed: Rigid galvanized steel or PVC-coated rigid steel conduit.

I. Under Equipment Mounting Pads: **[A: Rigid galvanized steel] [B: Intermediate metal] [C: PVC-coated rigid steel] [D: PVC Schedule 40] [E: PVC Schedule 80]** conduit.

J. Exterior Light Pole Foundations: Rigid galvanized steel conduit.

K. Corrosive Areas: PVC-coated rigid galvanized steel.

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3.04 FLEXIBLE CONNECTIONS

A. For motors, wall or ceiling mounted fans and unit heaters, dry type transformers, electrically operated valves, instrumentation, and other locations approved by Engineer where flexible connection is required to minimize vibration:

1. Conduit Size 4 Inches or Less: Flexible, liquid-tight conduit.
2. Conduit Size Over 4 Inches: Nonflexible.
3. Wet or Corrosive Areas: Flexible, nonmetallic **[A: or flexible metal]** liquid-tight.
4. Dry Areas: Flexible, metallic liquid-tight.
5. Hazardous Areas: Flexible coupling suitable for Class I, Division 1 and 2 areas.

B. Suspended Lighting Fixtures in Dry Areas: Flexible steel, nonliquid-tight conduit.

C. Outdoor Areas, Process Areas Exposed to Moisture, and Areas Required to be Oiltight and Dust-Tight: Flexible metal, liquid-tight conduit.

D. Flexible Conduit Length: 18 inches minimum, 60 inches maximum; sufficient to allow movement or adjustment of equipment.

3.05 PENETRATIONS

A. Make at right angles, unless otherwise shown.

B. Notching or penetration of structural members, including footings and beams, not permitted.

C. Fire-Rated Walls, Floors, or Ceilings: Firestop openings around penetrations to maintain fire-resistance rating **[A: using fire penetration seal as specified in Section 07 92 00, Joint Sealants] [B: as specified in Section 07 84 00, Firestopping] [C: as specified in Section 26 05 04, Basic Electrical Materials and Methods]**.

D. Apply heat shrinkable tubing or single layer of wraparound duct band to metallic conduit protruding through concrete floor slabs to a point 2 inches above and 2 inches below concrete surface.

E. Concrete Walls, Floors, or Ceilings (Aboveground): Provide nonshrink grout dry-pack, or use watertight seal device.

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F. Entering Structures:

1. General: Seal raceway at first box or outlet with oakum or expandable plastic compound to prevent entrance of gases or liquids from one area to another.
2. Concrete Roof or Membrane Waterproofed Wall or Floor:
    a. Provide a watertight seal.
    b. Without Concrete Encasement: Install watertight entrance seal device on each side.
    c. With Concrete Encasement: Install watertight entrance seal device on accessible side.
    d. Securely anchor malleable iron body of watertight entrance seal device into construction with one or more integral flanges.
    e. Secure membrane waterproofing to watertight entrance seal device in a permanent, watertight manner.
3. Heating, Ventilating, and Air Conditioning Equipment:
    a. Penetrate equipment in area established by manufacturer.
    b. Terminate conduit with flexible **[A: metal] [B: nonmetallic]** conduit at junction box or condulet attached to exterior surface of equipment prior to penetrating equipment.
    c. Seal penetration with Type 5 sealant, as specified in Section 07 92 00, Joint Sealants.
4. Corrosive-Sensitive Areas:
    a. Seal conduit passing through **[C: chlorine] [D: and] [E: ammonia]** room walls.
    b. Seal conduit entering equipment panel boards and field panels containing electronic equipment.
    c. Seal penetration with Type 5 sealant, as specified in Section 07 92 00, Joint Sealants.
5. Existing or Precast Wall (Underground): Core drill wall and install watertight entrance seal device.
6. Nonwaterproofed Wall or Floor (Underground, without Concrete Encasement):
    a. Provide Schedule 40 galvanized pipe sleeve, or watertight entrance seal device.
    b. Fill space between raceway and sleeve with expandable plastic compound or oakum and lead joint, on each side.
7. Manholes and Handholes:
    a. Metallic Raceways: Provide insulated grounding bushings.
    b. Nonmetallic Raceways: Provide bell ends flush with wall.
    c. Install such that raceways enter as near as possible to one end of wall, unless otherwise shown.

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3.06 SUPPORT

A. Support from structural members only, at intervals not exceeding NFPA 70 requirements. Do not exceed **10** feet in any application. Do not support from piping, pipe supports, or other raceways.

B. Multiple Adjacent Raceways: Provide ceiling trapeze. For trapeze-supported conduit, allow 25 percent extra space for future conduit.

C. Application/Type of Conduit Strap:

1. Aluminum Conduit: Aluminum or stainless steel.
2. Rigid Steel or EMT Conduit: Zinc coated steel, pregalvanized steel or malleable iron.
3. PVC-Coated Rigid Steel Conduit: PVC-coated metal.
4. Nonmetallic Conduit: Stainless steel, galvanized steel or PVC-coated metal.

D. Provide and attach wall brackets, strap hangers, or ceiling trapeze as follows:

1. Wood: Wood screws.
2. Hollow Masonry Units: Toggle bolts.
3. Concrete or Brick: Expansion shields, or threaded studs driven in by powder charge, with lock washers and nuts.
4. Steelwork: Machine screws.
5. Location/Type of Hardware:
    a. Dry, Noncorrosive Areas: Galvanized.
    b. Wet, Noncorrosive Areas: Stainless steel.
    c. Corrosive Areas: Stainless steel.

E. Nails or wooden plugs inserted in concrete or masonry for attaching raceway not permitted. Do not weld raceways or pipe straps to steel structures. Do not use wire in lieu of straps or hangers.

F. Support aluminum conduit on concrete surfaces with stainless steel or nonmetallic spacers, or aluminum or nonmetallic framing channel.

3.07 BENDS

A. Install concealed raceways with a minimum of bends in the shortest practical distance.

B. Make bends and offsets of longest practical radius. Bends in conduits and ducts being installed for fiber optic cables shall be not less than 20 times cable diameter, 15 inches minimum.

C. Install with symmetrical bends or cast metal fittings.

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D. Avoid field-made bends and offsets, but where necessary, make with acceptable hickey or bending machine. Do not heat metal raceways to facilitate bending.

E. Make bends in parallel or banked runs from same center or centerline with same radius so that bends are parallel.

F. Factory elbows may be installed in parallel or banked raceways if there is change in plane of run, and raceways are same size.

G. PVC Conduit:

1. Bends 30 Degrees and Larger: Provide factory-made elbows.
2. 90-Degree Bends: Provide rigid steel elbows, PVC-coated where direct buried.
3. Use manufacturer's recommended method for forming smaller bends.

H. Flexible Conduit: Do not make bends that exceed allowable conductor bending radius of cable to be installed or that significantly restricts conduit flexibility.

3.08 EXPANSION/DEFLECTION FITTINGS

A. Provide on raceways at structural expansion joints and in long tangential runs.

B. Provide expansion/deflection joints for 100 degrees F maximum temperature variation.

C. Install in accordance with manufacturer's instructions.

3.09 PVC CONDUIT

A. Solvent Welding:

1. Apply manufacturer recommended solvent to joints.
2. Install in order that joint is watertight.

B. Adapters:

1. PVC to Metallic Fittings: PVC terminal type.
2. PVC to Rigid Metal Conduit or IMC: PVC female adapter.

C. Belled-End Conduit: Bevel unbelled end of joint prior to joining.

3.10 PVC-COATED RIGID STEEL CONDUIT

A. Install in accordance with manufacturer's instructions.

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B. Tools and equipment used in cutting, bending, threading and installation of PVC-coated rigid conduit shall be designed to limit damage to PVC coating.

C. Provide PVC boot to cover exposed threading.

3.11 WIREWAYS

A. Install in accordance with manufacturer's instructions.

B. Locate with cover on accessible vertical face of wireway, unless otherwise shown.

C. Applications:

1. Metal wireway in indoor dry locations.
2. Nonmetallic wireway in indoor wet, outdoor, and corrosive locations.

3.12 CABLE TRAYS

A. Install in accordance with NEMA VE 1, section Application Information.

B. Install accessories as necessary for complete system.

C. Install in order that joints are not made at support brackets.

D. Install horizontal section support brackets between support point and quarter point of tray span.

E. Provide ceiling trapeze for horizontal cable tray.

F. Install support within 2 feet on each side of expansion joints and within 2 feet of fitting extremity.

G. Provide expansion joints in accordance with NEMA VE 1 for 100 degrees F maximum temperature variation.

H. Install horizontal tray level, plumb, straight, and true to line or grade within a tolerance of 1/8 inch in 10 feet and within a cumulative maximum of 1/2 inch.

I. Install vertical tray plumb within a tolerance of 1/8 inch in 10 feet.

J. Install without exposed raw edges.

K. Maintain 12-inch vertical separation between multi-tiered trays having a common support, and at crossover locations.

L. Provide bonding jumper at each expansion joint and adjustable connection.

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M. Ground Conductor: Provide properly sized clamps for each section, elbow, tee, cross, and reducer.

3.13 TERMINATION AT ENCLOSURES

A. Cast Metal Enclosure: Install manufacturer's premolded insulating sleeve inside metallic conduit terminating in threaded hubs.

B. Nonmetallic, Cabinets, and Enclosures:

1. Terminate conduit in threaded conduit hubs, maintaining enclosure integrity.
2. Metallic Conduit: Provide ground terminal for connection to maintain continuity of ground system.

C. Sheet Metal Boxes, Cabinets, and Enclosures:

1. General:
   a. Install insulated bushing on ends of conduit where grounding is not required.
   b. Provide insulated throat when conduit terminates in sheet metal boxes having threaded hubs.
   c. Utilize sealing locknuts or threaded hubs on sides and bottom of NEMA 3R and NEMA 12 enclosures.
   d. Terminate conduits at threaded hubs at the tops of NEMA 3R and NEMA 12 boxes and enclosures.
   e. Terminate conduits at threaded conduit hubs at NEMA 4 and NEMA 4X boxes and enclosures.
2. Rigid Galvanized or Aluminum Conduit:
   a. Provide one lock nut each on inside and outside of enclosure.
   b. Install grounding bushing at source enclosure.
   c. Provide bonding jumper from grounding bushing to equipment ground bus or ground pad.
3. Electric Metallic Tubing: Provide gland compression, insulated connectors.
4. Flexible Metal Conduit: Provide two screw type, insulated, malleable iron connectors.
5. Flexible, Nonmetallic Conduit: Provide nonmetallic, liquid-tight strain relief connectors.
6. PVC-Coated Rigid Galvanized Steel Conduit: Provide PVC-coated, liquid-tight, metallic connector.
7. PVC Schedule 40 Conduit: Provide PVC terminal adapter with lock nut, except where threaded hubs required above.

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D. Motor Control Center, Switchboard, Switchgear, and Free-Standing Enclosures:

1. Terminate metal conduit entering bottom with grounding bushing; provide grounding jumper extending to equipment ground bus or grounding pad.
2. Terminate PVC conduit entering bottom with bell end fittings.

3.14 UNDERGROUND RACEWAYS

A. Grade: Maintain minimum grade of 4 inches in 100 feet, either from one manhole, handhole, or pull box to the next, or from a high point between them, depending on surface contour.

B. Cover: Maintain minimum 2-foot cover above conduit unless otherwise shown.

C. Make routing changes as necessary to avoid obstructions or conflicts.

D. Couplings: In multiple conduit runs, stagger so couplings in adjacent runs are not in same transverse line.

E. Union type fittings not permitted.

F. Spacers:

1. Provide preformed, nonmetallic spacers designed for such purpose, to secure and separate parallel conduit runs in a trench or concrete encasement.
2. Install at intervals not greater than that specified in NFPA 70 for support of the type conduit used, but in no case greater than 10 feet.

G. Support conduit so as to prevent bending or displacement during backfilling or concrete placement.

H. Transition from Underground to Exposed: Rigid galvanized steel PVC-coated rigid steel conduit.

I. Installation with Other Piping Systems:

1. Crossings: Maintain minimum 12-inch vertical separation.
2. Parallel Runs: Maintain minimum 12-inch separation.
3. Installation over valves or couplings not permitted.

J. Metallic Raceway Coating: At couplings and joints, apply wraparound duct band with one-half tape width overlap to obtain two complete layers or apply heat shrinkable tubing.

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K. Provide expansion fittings that allow minimum of 4 inches of movement in vertical conduit runs from underground where exposed conduit will be fastened to building or structure.

L. Provide expansion/deflection fittings in conduit runs that exit building or structure belowgrade. Conduit from building wall to fitting shall be PVC-coated rigid steel.

M. Concrete Cap:

1. Provide an unreinforced concrete cap above conduit systems not indicated on the drawings as “DB” or “direct buried”.
   a. Width: Full width of the conduit system plus six inches on each side, minimum.
   b. Thickness: 4 inches, minimum.
   c. Depth to top of concrete: 18 inches below grade, nominal.
2. As specified in Section 03 30 00, Cast-in-Place Concrete.
3. Concrete Color: Red.

N. Backfill:

1. As specified in Section 31 23 23.15, Trench Backfill. Controlled low strength fill is an acceptable bedding and pipe zone material. Backfill material to within 12 inches of surface.
2. Do not backfill until inspected by CH2M.

3.15 UNDER SLAB RACEWAYS

A. Make routing changes as necessary to avoid obstructions or conflicts.

B. Support raceways so as to prevent bending or displacement during backfilling or concrete placement.

C. Install raceways with no part embedded within slab and with no interference with slab on grade construction.

D. Raceway spacing, in a single layer or multiple layers:

1. 3 inches clear between adjacent 2-inch or larger raceway.
2. 2 inches clear between adjacent 1-1/2-inch or smaller raceway.

E. Multiple Layers of Raceways: Install under slab on grade in trench below backfill zone, as specified in Section 31 23 23.15, Trench Backfill.

F. Individual Raceways and Single Layer Multiple Raceways: Install at lowest elevation of backfill zone with spacing as specified herein. Where conduits cross perpendicularly, installation of conduits shall not interfere with

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placement of under slab fill that meets compaction and void limitations of earthwork specifications.

G. Under slab raceways that emerge from below slab to top of slab as exposed, shall be located to avoid conflicts with structural slab rebar. Coordinate raceway stub ups with location of structural rebar.

H. Fittings:

1. Union type fittings are not permitted.
2. Provide expansion/deflection fittings in raceway runs that exit building or structure below slab. Locate fittings 18 inches, maximum, beyond exterior wall. Raceway type between building exterior wall to fitting shall be PVC-coated rigid steel.
3. Couplings: In multiple raceway runs, stagger so couplings in adjacent runs are not in same traverse line.

3.16 OUTLET AND DEVICE BOXES

A. General:

1. Install plumb and level.
2. Install suitable for conditions encountered at each outlet or device in wiring or raceway system, sized to meet NFPA 70 requirements.
3. Open no more knockouts in sheet steel device boxes than are required; seal unused openings.
4. Install galvanized mounting hardware in industrial areas.

B. Size:

1. Depth: Minimum 2 inches, unless otherwise required by structural conditions. Box extensions not permitted.
   a. Hollow Masonry Construction: Install with sufficient depth such that conduit knockouts or hubs are in masonry void space.
2. Ceiling Outlet: Minimum 4-inch octagonal device box, unless otherwise required for installed fixture.
3. Switch and Receptacle: Minimum 2-inch by 4-inch device box.

C. Locations:

1. Drawing locations are approximate.
2. To avoid interference with mechanical equipment or structural features, relocate outlets as directed by CH2M.
3. Light Fixture: Install in symmetrical pattern according to room layout, unless otherwise shown.

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D. Mounting Height:

1. General:
    a. Dimensions given to centerline of box.
    b. Where specified heights do not suit building construction or finish, adjust up or down to avoid interference.
    c. Do not straddle CMU block or other construction joints.
2. Light Switch:
    a. 48 inches above floor.
    b. When located next to door, install on lock side of door.
3. Thermostat: 54 inches above floor.
4. Telephone Outlet:
    a. 15 inches above floor.
    b. 6 inches above counter tops.
    c. Wall Mounted: 52 inches above floor.
5. Convenience Receptacle:
    a. General Interior Areas: 15 inches above floor.
    b. General Interior Areas (Counter Tops): Install device plate bottom or side flush with top of backsplash, or 6 inches above counter tops without backsplash.
    c. Industrial Areas, Workshops: 48 inches above floor.
    d. Outdoor Areas: 48 inches above finished grade.
6. Special-Purpose Receptacle: 48 inches above floor or as shown.
7. Disconnect switch, or local control station: 48 inches above floor, unless otherwise indicated on Drawings.

E. Flush Mounted:

1. Install with concealed conduit.
2. Install proper type extension rings or plaster covers to make edges of boxes flush with finished surface.
3. Holes in surrounding surface shall be no larger than required to receive box.

F. Supports:

1. Support boxes independently of conduit by attachment to building structure or structural member.
2. Install bar hangers in frame construction or fasten boxes directly as follows:
    a. Wood: Wood screws.
    b. Concrete or Brick: Bolts and expansion shields.
    c. Hollow Masonry Units: Toggle bolts.
    d. Steelwork: Machine screws.
3. Threaded studs driven in by powder charge and provided with lock washers and nuts are acceptable in lieu of expansion shields.

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4. Provide plaster rings where necessary.
5. Boxes embedded in concrete or masonry need not be additionally supported.

G. Install separate junction boxes for flush or recessed lighting fixtures where required by fixture terminal temperature.

H. Boxes Supporting Fixtures: Provide means of attachment with adequate strength to support fixture.

3.17 JUNCTION AND PULL BOXES

A. General:

1. Install plumb and level.
2. Installed boxes shall be accessible.
3. Do not install on finished surfaces.
4. Use outlet boxes as junction and pull boxes wherever possible and allowed by applicable codes.
5. Use conduit bodies as junction and pull boxes where no splices are required and allowed by applicable codes.
6. Install pull boxes where necessary in raceway system to facilitate conductor installation.
7. Install where shown and where necessary to terminate, tap-off, or redirect multiple conduit runs.
8. Install in conduit runs at least every 150 feet or after the equivalent of three right-angle bends.

B. Flush Mounted:

1. Install with concealed conduit.
2. Holes in surrounding surface shall be no larger than required to receive box.
3. Make edges of boxes flush with final surface.

C. Mounting Hardware:

1. Noncorrosive Dry Areas: Galvanized.
2. Noncorrosive Wet Areas: Stainless steel.
3. Corrosive Areas: Stainless steel.

D. Supports:

1. Support boxes independently of conduit by attachment to building structure or structural member.

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2. Install bar hangers in frame construction or fasten boxes directly as follows:
    a. Wood: Wood screws.
    b. Concrete or Brick: Bolts and expansion shields.
    c. Hollow Masonry Units: Toggle bolts.
    d. Steelwork: Machine screws.
3. Threaded studs driven in by powder charge and provided with lock washers and nuts are acceptable in lieu of expansion shields.
4. Boxes embedded in concrete or masonry need not be additionally supported.

E. At or Below Grade:

1. Install boxes for below grade conduit flush with finished grade in locations outside of paved areas, roadways, or walkways.
2. If adjacent structure is available, box may be mounted on structure surface just above finished grade in accessible but unobtrusive location.
3. Obtain CH2M's written acceptance prior to installation in paved areas, roadways, or walkways.
4. Use boxes and covers suitable to support anticipated weights.

F. Install Drain/breather fittings in NEMA 250 Type 4 and Type 4X enclosures.

3.18 TELEPHONE TERMINAL CABINET

A. Install with top of cabinet 6 feet above floor.

B. Door Opening: 120 degrees, minimum.

3.19 TELEPHONE AND DATA OUTLET

A. Provide empty 4-11/16-inch square, deep outlet box.

B. Provide blank single gang raised device cover if cables are not installed.

3.20 MANHOLES AND HANDHOLES

A. Excavate, shore, brace, backfill, and final grade in accordance with Section 31 23 16, Excavation, and Section 31 23 23.15, Trench Backfill.

B. Do not install until final raceway grading has been determined.

C. Install such that raceway enters at nearly right angle and as near as possible to end of wall, unless otherwise shown.

D. Grounding: As specified in Section 26 05 26, Grounding and Bonding for Electrical Systems.

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E. Identification: Field stamp covers with manhole or handhole number as shown. Stamped numbers to be 1-inch minimum height.

3.21 EQUIPMENT PADS

A. Do not install until final raceway grading has been determined.

B. Install on compacted native earth. Embed pads so that top of pad is 3 to 6 inches above the surrounding grade.

3.22 EMPTY RACEWAYS

A. Provide permanent, removable cap over each end.

B. Provide PVC plug with pull tab for underground raceways with end bells.

C. Provide nylon pull cord.

D. Identify, as specified in Article Identification Devices, with waterproof tags attached to pull cord at each end, and at intermediate pull point.

3.23 IDENTIFICATION DEVICES

A. Raceway Tags:

1. Identify origin and destination.
2. For exposed raceways, install tags at each terminus, near midpoint, and at minimum intervals of every 50 feet, whether in ceiling space or surface mounted.
3. Install tags at each terminus for concealed raceways.
4. Provide noncorrosive wire for attachment.

B. Warning Tape: Install approximately 12 inches above direct-buried underground raceways. For conduit systems with a concrete cap, install approximately 6 inches above the concrete cap. Align parallel to, and within 12 inches of, centerline of run.

C. Buried Raceway Marker:

1. Install at grade to indicate direction of underground raceway.
2. Install at bends and at intervals not exceeding 100 feet in straight runs.
3. Embed and secure to top of concrete base, sized 14 inches long, 6 inches wide, and 8 inches deep; top set flush with finished grade.

3.24 PROTECTION OF INSTALLED WORK

A. Protect products from effects of moisture, corrosion, and physical damage during construction.

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B. Provide and maintain manufactured watertight and dust-tight seals over conduit openings during construction.

C. Touch up painted conduit threads after assembly to cover nicks or scars.

D. Touch up coating damage to PVC-coated conduit with patching compound approved by manufacturer. Compound shall be kept refrigerated according to manufacturers' instructions until time of use.

END OF SECTION

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SECTION 26 08 00
COMMISSIONING OF ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   a. D877, Standard Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes.
   b. D923, Standard Practice for Sampling Electrical Insulating Liquids.
   c. D924, Standard Test Method for Dissipation Factor (or Power Factor) and Relative Permittivity (Dielectric Constant) of Electrical Insulating Liquids.
   d. D971, Standard Test Method for Interfacial Tension of Oil Against Water by the Ring Method.
   e. D974, Standard Test Method for Acid and Base Number by Color-Indicator Titration.
   f. D1298, Standard Test Method for Density, Relative Density (Specific Gravity), or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method.
   g. D1500, Standard Test Method for ASTM Color of Petroleum Products (ASTM Color Scale).
   h. D1524, Standard Test Method for Visual Examination of Used Electrical Insulating Oils of Petroleum Origin in the Field.
   i. D1533, Standard Test Method for Water in Insulating Liquids by Coulometric Karl Fischer Titration.
   j. D1816, Standard Test Method for Dielectric Breakdown Voltage of Insulating Oils of Petroleum Origin Using VDE Electrodes.
2. Institute of Electrical and Electronics Engineers (IEEE):
   a. 43, Recommended Practice for Testing Insulating Resistance of Rotating Machinery.
   b. 48, Standard Test Procedures and Requirements for Alternating-Current Cable Terminators Used on Shielded Cables Having Laminated Insulation Rated 2.5 kV through 765 kV or Extruded Insulation Rated 2.5kV through 500kV.
   c. 81, Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System.
   d. 95, Recommended Practice for Insulation Testing of AC Electric Machinery (2300V and Above) with High Direct Voltage.
   e. 386, Standard for Separable Insulated Connector Systems for Power Distribution Systems Above 600V.

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f. 400, Guide for Field Testing and Evaluation of the Insulation of Shielded Power Cable Systems.
g. 450, Recommended Practice for Maintenance, Testing, and Replacement of Vented Lead-Acid Batteries for Stationary Applications.
h. C2, National Electrical Safety Code.
i. C37.20.1, Standard for Metal-Enclosed Low Voltage Power Circuit Breaker Switchgear.
j. C37.20.2, Standard for Metal-Clad Switchgear.
k. C37.20.3, Standard for Metal-Enclosed Interrupter Switchgear.
l. C37.23, Standard for Metal-Enclosed Bus.
m. C62.33, Standard Test Specifications for Varistor Surge-Protective Devices.

3. Insulated Cable Engineers Association (ICEA):
   a. S-93-639, 5-46 kV Shielded Power Cables for Use in the Transmission and Distribution of Electric Energy.
   b. S-94-649, Concentric Neutral Cables Rated 5 through 46 kV.
   c. S-97-682, Standard for Utility Shielded Power Cables Rated 5 through 46 kV.
4. National Electrical Manufacturers Association (NEMA):
   a. AB 4, Guidelines for Inspection and Preventive Maintenance of Molded Case Circuit Breakers Used in Commercial and Industrial Applications.
   b. PB 2, Deadfront Distribution Switchboards.
   c. WC 74, 5-46 kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy.
5. InterNational Electrical Testing Association (NETA): ATS, Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems.
6. National Fire Protection Association (NFPA):
   a. 70, National Electrical Code (NEC).
   b. 70B, Recommended Practice for Electrical Equipment Maintenance.
   c. 70E, Standard for Electrical Safety in the Workplace.
   d. 101, Life Safety Code.
7. National Institute for Certification in Engineering Technologies (NICET).
8. Occupational Safety and Health Administration (OSHA): CFR 29, Part 1910, Occupational Safety and Health Standards.

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1.02 SUBMITTALS

A. Informational Submittals:

1. Submit 30 days prior to performing inspections or tests:
   a. Schedule for performing inspection and tests.
   b. List of references to be used for each test.
   c. Sample copy of equipment and materials inspection form(s).
   d. Sample copy of individual device test form.
   e. Sample copy of individual system test form.
2. Energization Plan: Prior to initial energization of electrical distribution equipment; include the following:
   a. Owner's representative sign-off form for complete and accurate arc flash labeling and proper protective device settings for equipment to be energized.
   b. Staged sequence of initial energization of electrical equipment.
   c. Lock-Out-Tag-Out plan for each stage of the progressive energization.
   d. Barricading, signage, and communication plan notifying personnel of newly energized equipment.
3. Submit test or inspection reports and certificates for each electrical item tested within 30 days after completion of test:
4. Operation and Maintenance Data:
   a. In accordance with Section 01 78 23, Operation and Maintenance Data.
   b. After test or inspection reports and certificates have been reviewed by Engineer and returned, insert a copy of each in Operation and Maintenance Manual.
5. Programmable Settings: At completion of Performance Demonstration Test, submit final hardcopy printout and electronic files on compact disc of as-left setpoints, programs, and device configuration files for:
   a. Protective relays.
   b. Intelligent overload relays.
   c. Variable frequency drives.
   d. Power metering devices.
   e. Uninterruptible power supplies.
   f. Electrical communications modules.

1.03 QUALITY ASSURANCE

A. Testing Firm Qualifications:

1. Corporately and financially independent organization functioning as an unbiased testing authority.
2. Professionally independent of manufacturers, suppliers, and installers of electrical equipment and systems being tested.

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3. Employer of engineers and technicians regularly engaged in testing and inspecting of electrical equipment, installations, and systems.
4. Supervising engineer accredited as Certified Electrical Test Technologist by NICET or NETA and having a minimum of 5 years' testing experience on similar projects.
5. Technicians certified by NICET or NETA.
6. Assistants and apprentices assigned to Project at ratio not to exceed two certified to one noncertified assistant or apprentice.
7. Registered Professional Engineer to provide comprehensive Project report outlining services performed, results of such services, recommendations, actions taken, and opinions.
8. In compliance with OSHA CFR 29, Part 1910.7 criteria for accreditation of testing laboratories or a full member company of NETA.

B. Test equipment shall have an operating accuracy equal to or greater than requirements established by NETA ATS.

C. Test instrument calibration shall be in accordance with NETA ATS.

1.04 SEQUENCING AND SCHEDULING

A. Perform inspection and electrical tests after equipment listed herein has been installed.

B. Perform tests with apparatus de-energized whenever feasible.

C. Inspection and electrical tests on energized equipment shall be:

1. Scheduled with Engineer prior to de-energization.
2. Minimized to avoid extended period of interruption to the operating plant equipment.

D. Notify Engineer at least 24 hours prior to performing tests on energized electrical equipment.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 GENERAL

A. Perform tests in accordance with requirements of Section 01 91 14, Equipment Testing and Facility Startup.

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B. Tests and inspections shall establish:

1. Electrical equipment is operational within industry and manufacturer's tolerances and standards.
2. Installation operates properly.
3. Equipment is suitable for energization.
4. Installation conforms to requirements of Contract Documents and NFPA 70, NFPA 70E, NFPA 101, and IEEE C2.

C. Perform inspection and testing in accordance with NETA ATS, industry standards, and manufacturer's recommendations.

D. Set, test, and calibrate protective relays, circuit breakers, fuses power monitoring meters, and other applicable devices in accordance with values established by short circuit, coordination, and harmonics studies as specified in Section 26 05 70, Electrical Systems Analysis.

E. Adjust mechanisms and moving parts of equipment for free mechanical movement.

F. Adjust and set electromechanical electronic relays and sensors to correspond to operating conditions, or as recommended by manufacturer.

G. Verify nameplate data for conformance to Contract Documents and approved Submittals.

H. Realign equipment not properly aligned and correct unlevelness.

I. Properly anchor electrical equipment found to be inadequately anchored.

J. Tighten accessible bolted connections, including wiring connections, with calibrated torque wrench/screw driver to manufacturer's recommendations, or as otherwise specified in NETA ATS.

K. Clean contaminated surfaces with cleaning solvents as recommended by manufacturer.

L. Provide proper lubrication of applicable moving parts.

M. Inform Engineer of working clearances not in accordance with NFPA 70.

N. Investigate and Repair or Replace:

1. Electrical items that fail tests.
2. Active components not operating in accordance with manufacturer's instructions.
3. Damaged electrical equipment.

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O. Electrical Enclosures:

1. Remove foreign material and moisture from enclosure interior.
2. Vacuum and wipe clean enclosure interior.
3. Remove corrosion found on metal surfaces.
4. Repair or replace, as determined by Engineer door and panel sections having dented surfaces.
5. Repair or replace, as determined by Engineer poor fitting doors and panel sections.
6. Repair or replace improperly operating latching, locking, or interlocking devices.
7. Replace missing or damaged hardware.
8. Finish:
    a. Provide matching paint and touch up scratches and mars.
    b. If required because of extensive damage, as determined by Engineer, refinish entire assembly.

P. Replace fuses and circuit breakers that do not conform to size and type required by the Contract Documents or approved Submittals.

Q. Replace transformer insulating oil not in compliance with ASTM D923.

3.02 CHECKOUT AND STARTUP

A. Voltage Field Test:

1. Check voltage at point of termination of power company supply system to Project when installation is essentially complete and is in operation.
2. Check voltage amplitude and balance between phases for loaded and unloaded conditions.
3. Record supply voltage (all three phases simultaneously on same graph) for 24 hours during normal working day.
    a. Submit Voltage Field Test Report within 5 days of test.
4. Unbalance Corrections:
    a. Make written request to power company to correct condition if balance (as defined by NEMA) exceeds 1 percent, or if voltage varies throughout the day and from loaded to unloaded condition more than plus or minus 4 percent of nominal.
    b. Obtain written certification from responsible power company official that voltage variations and unbalance are within their normal standards if corrections are not made.

B. Equipment Line Current Tests:

1. Check line current in each phase for each piece of equipment.
2. Make line current check after power company has made final adjustments to supply voltage magnitude or balance.

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3. If phase current for a piece of equipment is above rated nameplate current, prepare Equipment Line Phase Current Report that identifies cause of problem and corrective action taken.

3.03 SWITCHGEAR AND SWITCHBOARD ASSEMBLIES

A. Visual and Mechanical Inspection:

1. Insulator damage and contaminated surfaces.
2. Proper barrier and shutter installation and operation.
3. Proper operation of indicating devices.
4. Improper blockage of air-cooling passages.
5. Proper operation of drawout elements.
6. Integrity and contamination of bus insulation system.
7. Check door and device interlocking system by:
   a. Closure attempt of device when door is in OPEN position.
   b. Opening attempt of door when device is in CLOSED position.
8. Check nameplates for proper identification of:
   a. Equipment title and tag number with latest one-line diagram.
   b. Pushbutton.
   c. Control switch.
   d. Pilot light.
   e. Control relay.
   f. Circuit breaker.
   g. Indicating meter or power monitor.
9. Verify fuse and circuit breaker ratings, sizes, and types conform to those specified.
10. Check bus and cable connections for high resistance by low resistance ohmmeter and calibrated torque wrench applied to bolted joints.
    a. Ohmic value to be zero.
    b. Bolt torque level in accordance with NETA ATS, Table 100.12, unless otherwise specified by manufacturer.
11. Check operation and sequencing of electrical and mechanical interlock systems by:
    a. Closure attempt for locked open devices.
    b. Opening attempt for locked closed devices.
    c. Key exchange to operate devices in OFF-NORMAL positions.
12. Verify performance of each control device and feature.
13. Control Wiring:
    a. Compare wiring to local and remote control and protective devices with elementary diagrams.
    b. Proper conductor lacing and bundling.
    c. Proper conductor identification.
    d. Proper conductor lugs and connections.
14. Exercise active components.

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15. Perform phasing check on double-ended equipment to ensure proper bus phasing from each source.

B. Electrical Tests:

1. Insulation Resistance Tests:
   a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 100.1.
   b. Each phase of each bus section.
   c. Phase-to-phase and phase-to-ground for 1 minute.
   d. With switches and breakers open.
   e. Control wiring except that connected to solid state components.
   f. Insulation resistance values equal to, or greater than, ohmic values established by manufacturer.
2. Overpotential Tests:
   a. Applied **[G: ac] [H: or] [I: dc] voltage and test procedure in accordance with [J: IEEE [K: C37.20.1] [L: C37.20.2] [M: C37.20.3] [N: and] [O: NEMA PB 2].] [P: Alternatively use NETA ATS, Table 100.2.]**
   b. Each phase of each bus section.
   c. Phase-to-phase and phase-to-ground for 1 minute.
   d. Test results evaluated on a pass/fail basis.
3. Current Injection Tests:
   a. For entire current circuit in each section.
   b. Secondary injection for current flow of 1 ampere.
   c. Test current at each device.
4. Control Wiring:
   a. Apply secondary voltage to control power and potential circuits.
   b. Check voltage levels at each point on terminal boards and each device terminal.
5. Operational Test:
   a. Initiate control devices.
   b. Check proper operation of control system in each section.

3.04 PANELBOARDS

A. Visual and Mechanical Inspection: Include the following inspections and related work:

1. Inspect for defects and physical damage, labeling, and nameplate compliance with requirements of up-to-date drawings and panelboard schedules.
2. Exercise and perform operational tests of mechanical components and other operable devices in accordance with manufacturer’s instruction manual.

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3. Check panelboard mounting, area clearances, and alignment and fit of components.
4. Check tightness of bolted electrical connections with calibrated torque wrench. Refer to manufacturer's instructions for proper torque values.
5. Perform visual and mechanical inspection for overcurrent protective devices.

B. Electrical Tests: Include the following items performed in accordance with manufacturer's instruction:

1. Insulation Resistance Tests:
   a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 100.1.
   b. Each phase of each bus section.
   c. Phase-to-phase and phase-to-ground for 1 minute.
   d. With switches and breakers open.
   e. Control wiring except that connected to solid state components.
   f. Insulation resistance values equal to, or greater than, ohmic values established by manufacturer.
2. Ground continuity test ground bus to system ground.

3.05 DRY TYPE TRANSFORMERS

A. Visual and Mechanical Inspection:

1. Physical and insulator damage.
2. Proper winding connections.
3. Bolt torque level in accordance with NETA ATS, Table 100.12, unless otherwise specified by manufacturer.
4. Defective wiring.
5. Proper operation of fans, indicators, and auxiliary devices.
6. Removal of shipping brackets, fixtures, or bracing.
7. Free and properly installed resilient mounts.
8. Cleanliness and improper blockage of ventilation passages.
9. Verify tap-changer is set at correct ratio for rated output voltage under normal operating conditions.
10. Verify proper secondary voltage phase-to-phase and phase-to-ground after energization and prior to loading.

B. Electrical Tests:

1. Insulation Resistance Tests:
   a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 100.5 for each:
      1) Winding-to-winding.
      2) Winding-to-ground.

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b. Test Duration: 10 minutes with resistances tabulated at 30 seconds, 1 minute, and 10 minutes.
c. Results temperature corrected in accordance with NETA ATS, Table 100.14.
d. Temperature corrected insulation resistance values equal to, or greater than, ohmic values established by manufacturer.
e. Insulation resistance test results to compare within 1 percent of adjacent windings.

2. Perform tests and adjustments for fans, controls, and alarm functions as suggested by manufacturer.

3.06 LIQUID FILLED TRANSFORMERS

A. Visual and Mechanical Inspection:

1. Physical and insulator damage.
2. Proper winding connections.
3. Bolt torque level in accordance with NETA ATS, Table 100.12, unless otherwise specified by manufacturer.
4. Defective wiring.
5. Proper operation of fans, indicators, and auxiliary devices.
6. Effective core and equipment grounding.
7. Removal of shipping brackets, fixtures, or bracing.
8. Tank leaks and proper liquid level.
9. Integrity and contamination of bus insulation system.
10. Verify tap-changer is set at correct ratio for rated voltage under normal operating conditions.
11. Verify proper secondary voltage phase-to-phase and phase-to-ground after energization and prior to loading.

B. Electrical Tests:

1. Insulation Resistance Tests:
   a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 100.5 for each:
      1) Winding-to-winding.
      2) Winding-to-ground.
   b. Test Duration: 10 minutes with resistances tabulated at 30 seconds, 1 minute, and 10 minutes.
   c. Results temperature corrected in accordance with NETA ATS, Table 100.14.
   d. Temperature corrected insulation resistance values equal to, or greater than, ohmic values established by manufacturer.
   e. Insulation resistance test results to compare within 1 percent of adjacent windings.

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2. Perform tests and adjustments for fans, controls, and alarm functions as suggested by manufacturer.
3. Sample insulating oil in accordance with ASTM D923 and have laboratory test for:
    a. Dielectric breakdown voltage in accordance with ASTM D877 or ASTM D1816.
    b. Acid neutralization number in accordance with ASTM D974.
    c. Interfacial tension in accordance with ASTM D971.
    d. Color in accordance with ASTM D1500.
    e. Visual condition in accordance with ASTM D1524.
    f. Specific gravity in accordance with ASTM D1298.
    g. Water content, in parts per million, in accordance with ASTM D1533.
    h. Dielectric fluid test results in accordance with NETA ATS, Table 100.4.
    i. Power factor at 25 degrees C and at 100 degrees, in accordance with ASTM D924.
    j. Maximum power factor, corrected to 20 degrees C, in accordance with manufacturer's specifications.

3.07 LOW VOLTAGE CABLES, 600 VOLTS MAXIMUM

A. Visual and Mechanical Inspection:

1. Inspect each individual exposed power cable No. 6 and larger for:
    a. Physical damage.
    b. Proper connections in accordance with single-line diagram.
    c. Cable bends not in conformance with manufacturer's minimum allowable bending radius where applicable.
    d. Color coding conformance with specification.
    e. Proper circuit identification.
2. Mechanical Connections For:
    a. Proper lug type for conductor material.
    b. Proper lug installation.
    c. Bolt torque level in accordance with NETA ATS, Table 100.12, unless otherwise specified by manufacturer.
3. Shielded Instrumentation Cables For:
    a. Proper shield grounding.
    b. Proper terminations.
    c. Proper circuit identification.
4. Control Cables For:
    a. Proper termination.
    b. Proper circuit identification.
5. Cables Terminated Through Window Type CTs: Verify neutrals and grounds are terminated for correct operation of protective devices.

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B. Electrical Tests for Conductors No. 6 and Larger:

1. Insulation Resistance Tests:
   a. Utilize 1,000-volt dc megohmmeter for 600-volt insulated conductors and 500-volt dc megohmmeter for 300-volt insulated conductors.
   b. Test each conductor with respect to ground and to adjacent conductors for 1 minute.
   c. Evaluate ohmic values by comparison with conductors of same length and type.
   d. Investigate values less than 50 megohms.
2. Continuity test by ohmmeter method to ensure proper cable connections.

C. Low-voltage cable tests may be performed by installer in lieu of independent testing firm.

3.08 MEDIUM-VOLTAGE CABLES, 25 KV MAXIMUM

A. Visual and Mechanical Inspection:

1. Inspect each individual exposed cable for:
   a. Physical damage plus jacket and insulation condition.
   b. Proper connections in accordance with single-line diagram or approved Submittals.
   c. Proper shield grounding.
   d. Proper cable support.
   e. Proper cable termination.
   f. Cable bends not in conformance with manufacturer's minimum allowable bending radius.
   g. Proper arc and fireproofing in common cable areas.
   h. Proper circuit and phase identification.
2. Mechanical Connections:
   a. Proper lug type for conductor material.
   b. Proper lug installation.
   c. Bolt torque level in accordance with NETA ATS, Table 100.12, unless otherwise specified by manufacturers.
3. Conductors Terminated Through Window Type CTs: Verify neutrals and grounds are terminated for correct operation of protective devices.

B. Electrical Tests:

1. Insulation Resistance Tests:
   a. Utilize **[C: 5,000-volt megohmmeter for 8 kV and 15 kV conductors].**
   b. Test each cable individually with remaining cables and shields grounded.

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c. Test each conductor with respect to ground and to adjacent conductors for 1 minute.
d. Evaluate ohmic values by comparison with conductors of same length and type.
e. Investigate values less than 50 megohms.

2. Shield Continuity Tests:
   a. By ohmmeter method on each section of conductor.
   b. Investigate values in excess of 10 ohms per 1,000 feet of conductors.
3. Acceptance Tests:
   a. In accordance with IEEE 400, ICEA S-93-639, NEMA WC 74, ICEA S-94-649, and ICEA S-97-682 for insulated conductors.
   b. Each conductor section tested with:
      1) Splices and terminations in place but disconnected from equipment.
      2) Remaining conductors and shields grounded in accordance with IEEE 400.
   c. Apply maximum test voltage per NETA ATS, Table 100.6, based on method (DC, AC, PD or VLF) used.
   d. Measure only leakage current associated with conductor.
   e. Utilize guard ring or field reduction sphere to suppress corona at disconnected terminations.
   f. Maximum test voltage shall not exceed limits for terminators specified in IEEE 48, IEEE 386, or manufacturer's specifications.
   g. Apply test voltage in a minimum of five equal increments until maximum acceptable test voltage is reached.
      1) Increments not to exceed ac voltage rating of conductor.
      2) Record dc leakage current at each step after a constant stabilization time consistent with system charging current.
   h. Raise conductor to specified maximum test voltage and hold for 15 minutes or as specified by conductor manufacturer. Record leakage current at 30 seconds and 1 minute, and at 1-minute intervals, thereafter.
   i. Immediately following test, ground conductor for adequate time period to drain insulation stored charge.
   j. Test results evaluated on a pass/fail basis.
4. New Conductors Spliced to Existing Conductors:
   a. Prior to performing splices, high potential dc test new conductor sections.
   b. After splicing new conductors to existing conductors, disconnect existing conductors and perform the following tests:
      1) Shield continuity test.
      2) Insulation resistance test.
      3) High potential test with test voltage not to exceed 60 percent of applied acceptance dc test voltage.

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3.09 SAFETY SWITCHES, 600 VOLTS MAXIMUM

A. Visual and Mechanical Inspection:

1. Proper blade pressure and alignment.
2. Proper operation of switch operating handle.
3. Adequate mechanical support for each fuse.
4. Proper contact-to-contact tightness between fuse clip and fuse.
5. Cable connection bolt torque level in accordance with NETA ATS, Table 100.12.
6. Proper phase barrier material and installation.
7. Verify fuse sizes and types correspond to one-line diagram or approved Submittals.
8. Perform mechanical operational test and verify electrical interlocking system operation and sequencing.

B. Electrical Tests:

1. Insulation Resistance Tests:
   a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 100.1.
   b. Phase-to-phase and phase-to-ground for 1 minute on each pole.
   c. Insulation resistance values equal to, or greater than, ohmic values established by manufacturer.
2. Contact Resistance Tests:
   a. Contact resistance in microhms across each switch blade and fuse holder.
   b. Investigate deviation of 50 percent or more from adjacent poles or similar switches.

3.10 MOLDED AND INSULATED CASE CIRCUIT BREAKERS

A. General: Inspection and testing limited to circuit breakers rated 100 amperes and larger and to motor circuit protector breakers rated 100 amperes and larger.

B. Visual and Mechanical Inspection:

1. Proper mounting.
2. Proper conductor size.
3. Feeder designation according to nameplate and one-line diagram.
4. Cracked casings.
5. Connection bolt torque level in accordance with NETA ATS, Table 100.12.
6. Operate breaker to verify smooth operation.
7. Compare frame size and trip setting with circuit breaker schedules or one-line diagram.

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8. Verify that terminals are suitable for 75 degrees C rated insulated conductors.

C. Electrical Tests:

1. Insulation Resistance Tests:
   a. Utilize 1,000-volt dc megohmmeter for 480-volt and 600-volt circuit breakers and 500-volt dc megohmmeter for 240-volt circuit breakers.
   b. Pole-to-pole and pole-to-ground with breaker contacts opened for 1 minute.
   c. Pole-to-pole and pole-to-ground with breaker contacts closed for 1 minute.
   d. Test values to comply with NETA ATS, Table 100.1.
2. Contact Resistance Tests:
   a. Contact resistance in microhms across each pole.
   b. Investigate deviation of 50 percent or more from adjacent poles and similar breakers.
3. Primary Current Injection Test to Verify:
   a. Long-time minimum pickup and delay.
   b. Short-time pickup and delay.
   c. Ground fault pickup and delay.
   d. Instantaneous pickup by run-up or pulse method.
   e. Trip characteristics of adjustable trip breakers shall be within manufacturer's published time-current characteristic tolerance band, including adjustment factors.
   f. Trip times shall be within limits established by NEMA AB 4, Table 5-3. Alternatively, use NETA ATS, Table 100.7.
   g. Instantaneous pickup value shall be within values established by NEMA AB 4, Table 5-4. Alternatively, use NETA ATS, Table 100.8.

3.11 LOW VOLTAGE POWER CIRCUIT BREAKERS

A. Visual and Mechanical Inspection:

1. Proper mounting, cell fit, and element alignment.
2. Proper operation of racking interlocks.
3. Check for damaged arc chutes.
4. Proper contact condition.
5. Bolt torque level in accordance with NETA ATS, Table 100.12.
6. Perform mechanical operational and contact alignment tests in accordance with manufacturer's instructions.
7. Check operation of closing and tripping functions of trip devices by activating ground fault relays, undervoltage shunt relays, and other auxiliary protective devices.

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8. Verify primary and secondary contact wipe, gap setting, and other dimensions vital to breaker operation are correct.
9. Check charging motor, motor brushes, associated mechanism, and limit switches for proper operation and condition.
10. Check operation of electrically operated breakers in accordance with manufacturer's instructions.
11. Check for adequate lubrication on contact, moving, and sliding surfaces.

B. Electrical Tests:

1. Insulation Resistance Tests:
   a. Utilize 1,000-volt dc megohmmeter for 480-volt and 600-volt circuit breakers.
   b. Pole-to-pole and pole-to-ground with breaker contacts opened for 1 minute.
   c. Pole-to-pole and pole-to-ground with breaker contacts closed for 1 minute.
   d. Test values to comply with NETA ATS, Table 100.1.
2. Contact Resistance Tests:
   a. Contact resistance in microhms across each pole.
   b. Investigate deviation of 50 percent or more from adjacent poles and similar breakers.
3. Primary Current Injection Test to Verify:
   a. Long-time minimum pickup and delay.
   b. Short-time pickup and delay.
   c. Ground fault pickup and delay.
   d. Instantaneous pickup by run-up or pulse method.
   e. Trip characteristic when adjusted to setting sheet parameters shall be within manufacturer's published time-current tolerance band.

3.12 MEDIUM-VOLTAGE VACUUM CIRCUIT BREAKERS

A. Visual and Mechanical Inspection:

1. Check for proper element alignment.
2. Check for proper operation of cubicle shutters and racking mechanism.
3. Bolt torque level in accordance with NETA ATS, Table 100.12.
4. Perform mechanical operational tests on breaker and its operating mechanism in accordance with manufacturer's instructions, plus check:
   a. Pull rod adjustment.
   b. Trip latch clearance.
   c. Overtravel stops.
   d. Wipe and gap setting.
5. Perform breaker travel and velocity analysis in accordance with manufacturer's instructions; values shall be in accordance with manufacturer's acceptable limits.

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6. Check contact erosion indicators in accordance with manufacturer's instructions.
7. With Breaker in TEST Position:
    a. Trip and close breaker with control switch.
    b. Trip breaker by manually operating each protective relay.

B. Electrical Tests:

1. Insulation Resistance Tests:
    a. Utilize 2,500-volt dc megohmmeter for **[A: 5-kV] [B: and] [C: 15-kV]** circuit breakers.
    b. Pole-to-pole and pole-to-ground with breaker contacts opened for 1 minute.
    c. Pole-to-pole and pole-to-ground with breaker contacts closed for 1 minute.
    d. Test values to comply with NETA ATS, Table 100.1.
2. Contact Resistance Tests:
    a. Between the line and load stab of closed contact resistance in microhms across each pole.
    b. Investigate deviation of 50 percent or more from adjacent poles and similar breakers.
3. Overpotential Tests:
    a. Maximum applied **[D: ac] [E: or] [F: dc]** voltage in accordance with NETA ATS, Table 100.19.
    b. Each pole-to-ground with other poles grounded and contacts closed for 1 minute.
    c. Test results evaluated on pass/fail basis.
4. Minimum pickup voltage tests on trip and close coils.
5. Control Wiring Tests:
    a. Insulation resistance test at 1,000-volt dc on control wiring, except that connected to solid state components.
    b. Insulation resistance to be 1 megohm minimum.
6. Vacuum bottle overpotential integrity test across each vacuum bottle with breaker in OPEN position, in accordance with manufacturer's instructions.
7. Power Factor Test (Each Phase):
    a. With breaker in both OPEN and CLOSED position.
    b. Compare power factor and arc chute watt loss with adjacent poles or manufacturer's published data.
8. Power Factor Test (Each Bushing):
    a. Utilize conductive straps and hot collar procedures if bushings are not equipped with power factor tap.
    b. Power factor and capacitance test results within nameplate rating of bushings.

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3.13 PROTECTIVE RELAYS

A. Visual and Mechanical Inspection:

1. Visually check each relay for:
    a. Tight cover gasket and proper seal.
    b. Unbroken cover glass.
    c. Condition of spiral spring and contacts.
    d. Disc clearance.
    e. Condition of case shorting contacts if present.
2. Mechanically check each relay for:
    a. Freedom of movement.
    b. Proper travel and alignment.
3. Upload relay programming files into the relay.
    a. Programming files to include protective element settings and operating logic.
    b. Update relay firmware.
4. Verify each relay:
    a. Complies with Contract Documents, approved Submittal, and application.
    b. Is set in accordance with recommended settings from Coordination Study.

B. Electrical Tests:

1. Insulation resistance test on each circuit to frame, except for solid state devices.
2. Test on nominal recommended setting for:
    a. Pickup parameters on each operating element.
    b. Timing at three points on time-current curve.
    c. Pickup target and seal-in units.
    d. Special tests as required to check operation of restraint, directional, and other elements in accordance with manufacturer's instruction manual.
3. Phase angle and magnitude contribution tests on differential and directional relays after energization to vectorially verify proper polarity and connections.
4. Current Injection Tests:
    a. For entire current circuit in each section.
    b. Secondary injection for current flow of 1 ampere.
    c. Test current at each device.

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3.14 INSTRUMENT TRANSFORMERS

A. Visual and Mechanical Inspection:

1. Visually check current, potential, and control transformers for:
   a. Cracked insulation.
   b. Broken leads or defective wiring.
   c. Proper connections.
   d. Adequate clearances between primary and secondary circuit wiring.
2. Verify Mechanically:
   a. Grounding and shorting connections have good contact.
   b. Withdrawal mechanism and grounding operation, when applicable, operate properly.
3. Verify proper primary and secondary fuse sizes for potential transformers.

B. Electrical Tests:

1. Current Transformer Tests:
   a. Insulation resistance test of transformer and wiring-to-ground at 1,000 volts dc for 30 seconds.
   b. Polarity test.
2. Potential Transformer Tests:
   a. Insulation resistance test at test voltages in accordance with NETA ATS, Table 100.9, for 1 minute on:
      1) Winding-to-winding.
      2) Winding-to-ground.
   b. Polarity test to verify polarity marks or H1-X1 relationship as applicable.
3. Insulation resistance measurement on instrument transformer shall not be less than that shown in NETA ATS, Table 100.5.

3.15 METERING

A. Visual and Mechanical Inspection:

1. Verify meter connections in accordance with appropriate diagrams.
2. Verify meter current and voltage multipliers.
3. Verify meter types and scales conform to Contract Documents.
4. Use separate digital multimeter to verify current and voltage readings.
5. Check calibration of meters at cardinal points.
6. Check calibration of electrical transducers.

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3.16 GROUNDING SYSTEMS

A. Visual and Mechanical Inspection:

1. Equipment and circuit grounds in motor control centers, panelboards, switchboard, and switchgear assemblies for proper connection and tightness.
2. Ground bus connections in motor control center, panelboard, switchboard, and switchgear assemblies for proper termination and tightness.
3. Effective transformer core and equipment grounding.
4. Accessible connections to grounding electrodes for proper fit and tightness.
5. Accessible exothermic-weld grounding connections to verify that molds were fully filled and proper bonding was obtained.

B. Electrical Tests:

1. Fall-of-Potential Test:
   a. In accordance with IEEE 81, Section 8.2.1.5 for measurement of main ground system's resistance.
   b. Main ground electrode system resistance to ground to be no greater than **[A: 1] [B: 3] [C: 5]** ohm(s).
2. Two-Point Direct Method Test:
   a. In accordance with IEEE 81, Section 8.2.1.1 for measurement of ground resistance between main ground system, equipment frames, and system neutral and derived neutral points.
   b. Equipment ground resistance shall not exceed main ground system resistance by **[D: 0.25] [E: 0.50]** ohm.
3. Neutral Bus Isolation:
   a. Test each neutral bus individually with neutral bonding jumper removed at service entrance or separately derived system.
   b. Evaluate ohmic values by measuring resistance between ground bus and neutral bus.
   c. Investigate values less than 50 megohms.

3.17 GROUND FAULT SYSTEMS

A. Inspection and testing limited to:

1. Zero sequence grounding systems.
2. Residual ground fault systems.

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B. Visual and Manual Inspection:

1. Neutral main bonding connection to ensure:
    a. Zero sequence sensing system is grounded ahead of neutral disconnect link.
    b. Ground strap sensing system is grounded through sensing device.
    c. Neutral ground conductor is solidly grounded.
2. Verify control power has adequate capacity for system.
3. Manually operate monitor panels for:
    a. Trip test.
    b. No trip test.
    c. Nonautomatic rest.
4. Zero sequence system for symmetrical alignment of core balance transformers about current carrying conductors.
5. Relay check for pickup and time under simulated ground fault conditions.
6. Verify nameplate identification by device operation.

C. Electrical Tests:

1. Test system neutral insulation resistance with neutral ground link removed; minimum 1 megohm.
2. Determine relay pickup by primary current injection at the sensor. Relay pickup current within plus or minus 10 percent of device dial or fixed setting.
3. Test relay timing by injecting 300 percent of pick-up current or as specified by manufacturer. Relay operating time in accordance with manufacturer's time-current characteristic curves.
4. Test system operation at 55 percent rated control voltage, if applicable.
5. Test zone interlock system by simultaneous sensor current injection and monitoring zone blocking functions.

3.18 AC INDUCTION MOTORS

A. General: Inspection and testing limited to motors rated 1 horsepower and larger.

B. Visual and Mechanical Inspection:

1. Proper electrical and grounding connections.
2. Shaft alignment.
3. Blockage of ventilating air passageways.
4. Operate motor and check for:
    a. Excessive mechanical and electrical noise.
    b. Overheating.
    c. Correct rotation.

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d. Check vibration detectors, resistance temperature detectors, or motor inherent protectors for functionability and proper operation.
e. Excessive vibration, in excess of values in NETA ATS, Table 100.10.

5. Check operation of space heaters.

C. Electrical Tests:

1. Insulation Resistance Tests:
   a. In accordance with IEEE 43 at test voltages established by NETA ATS, Table 100.1 for:
      1) Motors above 200 horsepower for 10-minute duration with resistances tabulated at 30 seconds, 1 minute, and 10 minutes.
      2) Motors 200 horsepower and less for 1-minute duration with resistances tabulated at 30 seconds and 60 seconds.
   b. Insulation resistance values equal to, or greater than, ohmic values established by manufacturers.
2. Calculate polarization index ratios for motors above 200 horsepower. Investigate index ratios less than 1.5 for Class A insulation and 2.0 for Class B insulation.
3. Insulation resistance test on insulated bearings in accordance with manufacturer's instructions.
4. Measure running current and voltage, and evaluate relative to load conditions and nameplate full-load amperes.

3.19 LOW-VOLTAGE MOTOR CONTROL

A. Visual and Mechanical Inspection:

1. Proper barrier and shutter installation and operation.
2. Proper operation of indicating and monitoring devices.
3. Proper overload protection for each motor.
4. Improper blockage of air-cooling passages.
5. Proper operation of drawout elements.
6. Integrity and contamination of bus insulation system.
7. Check door and device interlocking system by:
   a. Closure attempt of device when door is in or OPEN position.
   b. Opening attempt of door when device is in ON or CLOSED position.
8. Check nameplates for proper identification of:
   a. Equipment title and tag number with latest one-line diagram.
   b. Pushbuttons.
   c. Control switches.
   d. Pilot lights.
   e. Control relays.

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f. Circuit breakers.
g. Indicating meters and digital power monitors.

9. Verify fuse and circuit breaker sizes and types conform to Contract Documents.
10. Verify current and potential transformer ratios conform to Contract Documents.
11. Check bus connections for high resistance by low-resistance ohmmeter and calibrated torque wrench applied to bolted joints:
12. Ohmic value to be zero. Bolt torque level in accordance with NETA ATS, Table 100.12, unless otherwise specified by manufacturer.
13. Check operation and sequencing of electrical and mechanical interlock systems by:
    a. Closure attempt for locked open devices.
    b. Opening attempt for locked closed devices.
    c. Key exchange to operate devices in OFF-NORMAL positions.
14. Verify performance of each control device and feature furnished as part of motor control center.
15. Control Wiring:
    a. Compare wiring to local and remote control, and protective devices with elementary diagrams.
    b. Check for proper conductor lacing and bundling.
    c. Check for proper conductor identification.
    d. Check for proper conductor lugs and connections.
16. Exercise active components.
17. Inspect contactors for:
    a. Correct mechanical operations.
    b. Correct contact gap, wipe, alignment, and pressure.
    c. Correct torque of connections.
18. Compare overload heater rating with full-load current for proper size.
19. Compare motor protector with motor characteristics for proper size.
20. Perform phasing check on double-ended motor control centers to ensure proper bus phasing from each source.

B. Electrical Tests:

1. Insulation Resistance Tests:
    a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 100.1.
    b. Bus section phase-to-phase and phase-to-ground for 1 minute on each phase.
    c. Contactor phase-to-ground and across open contacts for 1 minute on each phase.
    d. Starter section phase-to-phase and phase-to-ground on each phase with starter contacts closed and protective devices open.
    e. Test values to comply with NETA ATS, Table 100.1.

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2. Current Injection through Overload Unit at 300 Percent of Motor Full-Load Current and Monitor Trip Time:
    a. Trip time in accordance with manufacturer's published data.
    b. Investigate values in excess of 120 seconds.
3. Control Wiring Tests:
    a. Apply secondary voltage to control power and potential circuits.
    b. Check voltage levels at each point on terminal board and each device terminal.
    c. Insulation resistance test at 1,000 volts dc on control wiring, except that connected to solid state components; 1 megohm minimum insulation resistance.
4. Operational test by initiating control devices to affect proper operation.

3.20 AUTOMATIC TRANSFER SWITCHES

A. Visual and Mechanical Inspection:

1. Check doors and panels for proper interlocking.
2. Check connections for high resistance by low-resistance ohmmeter calibrated torque wrench applied to bolted joints.
3. Check positive mechanical and electrical interlock between normal and alternate sources.
4. Check for proper operation:
    a. Manual transfer function switch.
    b. Generator under load and nonload conditions.
    c. Auto-exerciser of generator under load and no-load conditions.
5. Verify settings and operation of control devices.

B. Electrical Tests:

1. Insulation Resistance Tests:
    a. Applied megohmmeter dc voltage in accordance with NETA ATS, Table 100.1, for each phase with switch CLOSED in both source positions.
    b. Phase-to-phase and phase-to-ground for 1 minute.
    c. Test values in accordance with manufacturer's published data.
2. Contact Resistance Test:
    a. Contact resistance in microhms across each switch blade for both source positions.
    b. Investigate values exceeding 500 micro-ohms.
    c. Investigate values deviating from adjacent pole by more than 50 percent.
3. Set and calibrate in accordance with Specifications, manufacturer's recommendations, and **[A: Coordination Study] [B: or] [C: information provided by _____].**

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a. Voltage and frequency sensing relays.
b. Time delay relays.
c. Engine start and shutdown relays.

4. Perform automatic transfer tests by:
   a. Simulating loss of normal power.
   b. Return to normal power.
   c. Simulating loss of alternate power.
   d. Simulating single-phase conditions for normal and alternate sources.
5. Monitor and verify operation and timing of:
   a. Normal and alternate voltage sensing relays.
   b. Engine-start sequence.
   c. Timing delay upon transfer and retransfer.
   d. Engine cool down and shutdown.
   e. Interlocks and limit switch functions.
   f. Engine cool down and shutdown feature.

3.21 BATTERY SYSTEM

A. Visual and Mechanical Inspection:

1. Physical damage and electrolyte leakage.
2. Evidence of corrosion.
3. Intercell bus link integrity.
4. Battery cable insulation damage and contaminated surfaces.
5. Operating conditions of ventilating equipment.
6. Visual check of electrolyte level.

B. Electrical Tests:

1. Measure:
   a. Bank charging voltage.
   b. Individual cell voltage.
   c. Electrolyte specific gravity in each cell.
   d. Measured test values to be in accordance with manufacturer’s published data.
2. Verify during recharge mode:
   a. Charging rates from charger.
   b. Individual cell acceptance of charge.
3. Load tests for integrity and capacity; test values in accordance with IEEE 450.

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3.22 LOW VOLTAGE SURGE ARRESTORS

A. Visual and Mechanical Inspection:

1. Adequate clearances between arrestors and enclosures.
2. Ground connections to ground **[A: bus] [B: electrode].**

B. Electrical Tests:

1. Varistor Type Arrestors:
   a. Clamping voltage test.
   b. Rated RMS voltage test.
   c. Rated dc voltage test.
   d. Varistor arrestor test values in accordance with IEEE C62.33, Section 4.4 and Section 4.9.

3.23 MEDIUM-VOLTAGE SURGE ARRESTORS AND SURGE CAPACITORS

A. Visual Inspection:

1. Ground connections to ground electrode.
2. Shortest practical jumper connections to line.

B. Electrical Tests:

1. Grounding electrode resistance test in accordance with IEEE 81, Section 8.2.1.5 using three-point fall-of-potential method.
2. Insulation power factor.
3. Insulation resistance.
4. RF noise test using Stoddart noise test set with applied voltage of 1.18 times maximum continuous operating voltage.
5. Insulation power factor leakage current, watts loss, and insulation resistance test in accordance with manufacturer’s test values. RIV value not to exceed 10 microvolts above background noise.
6. Leakage current and watts loss tests.

3.24 STANDBY GENERATOR SYSTEMS

A. Visual and Mechanical Inspection:

1. Proper grounding.
2. Blockage of ventilating passageways.
3. Proper operation of jack water heaters.
4. Integrity of engine cooling and fuel supply systems.
5. Excessive mechanical and electrical noise.
6. Overheating of engine or generator.
7. Proper installation of vibration isolators.

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8. Proper cooling liquid type and level.
9. Operate engine-generator and check for:
    a. Excessive mechanical and electrical noise.
    b. Overheating.
    c. Correct rotation.
    d. Check resistance temperature detectors or generator inherent thermal protectors for functionability and proper operation.
    e. Excessive vibration.
10. Verify voltage regulator and governor operation will cause unit speed and output voltage to stabilize at proper values within reasonable length of time.
11. Proper operation of meters and instruments.
12. Compare generator nameplate rating and connection with one-line diagram or approved Submittal.
13. Verify engine-generator operation with system energized and operating under normal load conditions.

B. Electrical and Mechanical Tests:

1. Cold start test by interrupting normal power source with test load consisting of connected building load to verify:
    a. Transfer switch operation.
    b. Automatic starting operation.
    c. Operating ability of engine-generator.
    d. Overcurrent devices capability to withstand inrush currents.
2. Phase rotation tests.
3. Test engine protective shutdown features for:
    a. Low oil pressure.
    b. Overtemperature.
    c. Overspeed.
4. Vibration baseline test on generator sets rated above 250 kW; levels in accordance with manufacturer’s recommendations.
5. Load bank test with reactors and resistors adjusted to 80 percent power factor for each load step. Record voltage, frequency, load current, oil pressure, and engine coolant temperature at 15-minute intervals:
    a. 25 percent applied load for 30 minutes.
    b. 50 percent applied load for 30 minutes.
    c. 75 percent applied load for 30 minutes.
    d. 100 percent applied load for 3 hours.
    e. Load test results to demonstrate ability of unit to deliver rated load for test period.
6. One-Step Rated kW Load Pickup Test:
    a. Perform test immediately after performing load bank test.
    b. Apply rated load, minus largest rated hp motor, to generator.

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c. Start largest rated horsepower motor and record voltage drop for 20 cycles minimum with high-speed chart recorder or digital storage oscilloscope.
d. Compare voltage drop with maximum allowable voltage dip for specified starting situation.

END OF SECTION

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SECTION 26 09 13
POWER MEASUREMENT AND CONTROL

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American National Standards Institute (ANSI).
2. Institute for Electrical and Electronics Engineers, Inc. (IEEE):
   a. C37.90, Standard for Relays and Relay Systems Associated with Electric Power Apparatus.
   b. C37.90.1, Standard for Surge Withstand Capability (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus.
   c. C57.13, Standard Requirements for Instrument Transformers.
3. International Electrotechnical Commission (IEC):
   a. 60255-5, Electrical Relays—Part 5: Insulation Coordination for Measuring Relays and Protection Equipment—Requirements and Tests.
   b. 60255-22-4, Measuring Relays and Protection Equipment—Part 22-4: Electrical Disturbance Tests—Electrical Fast Transient/Burst Immunity Tests.
   c. 60688, Electrical Measuring Transducers for Converting a.c. Electrical Quantities to Analogue or Digital Signals.
   d. 60870-5-104, Telecontrol Equipment and Systems—Part 5-104: Transmission Protocols—Network Access for IEC 60870-5-101 Using Standard Transport Profiles.
   e. 61850, Communication Network and Systems in Substations.
4. Telecommunications Industry Association (TIA):
   a. 232-F, Interface between Data Terminal Equipment and Data Circuit-Terminating Equipment Employing Serial Binary Data Interchange.
   b. 485-A, Electrical Characteristics of Generators and Receivers for Use in Balanced Digital Multipoint Systems.
5. National Electrical Manufacturers Association (NEMA):
   a. C12.1, Electric Meters Code for Electricity Metering.
   b. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).

1.02 DEFINITIONS

A. AFD: Adjustable Frequency Drive.

B. CT: Current Transformer.

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C. DNP: Distributed Network Protocol.

D. LCD: Liquid Crystal Display.

E. LED: Light Emitting Diode.

F. MPR: Motor Protection Relay.

G. PLC: Programmable Logic Controller.

H. RTD: Resistance Temperature Detectors.

I. UCA: Utility Communications Architecture.

J. VT: Voltage Transformer.

1.03 SUBMITTALS

A. Action Submittals:

1. Instruction manuals for each type of device.
2. Special features, licensed programming software.
3. Potential and current schematic diagrams.
4. Control and metering schematic diagrams.
5. Interconnection wiring diagrams.
6. Installation and mounting requirements.
7. Complete descriptive literature and renewal parts data.

B. Informational Submittals:

1. Programming software used to configure devices, along with settings files necessary to reload or revise settings as left by Contractor.
2. Operation and Maintenance Data as specified in Section 01 78 23, Operation and Maintenance Data.

PART 2 PRODUCTS

2.01 MULTIFUNCTION TRANSFORMER PROTECTION RELAY

A. Manufacturer:

1. GE Multilin 345.
2. Schweitzer Engineering Laboratories SEL-487.

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2.02 POWER METER (PM)

A. General:

1. Solid state device with LED displays.
2. Direct voltage input up to 600V ac.
3. Current input via current transformer with 5-ampere secondary.
4. Programmable current and potential transformer ratios.
5. Programmable limits to activate up to four alarms.
6. Selectable Voltage Measurements: Line-to-line or line-to-neutral and wye or delta.
7. Ethernet capable.

B. Selectable Display:

1. Volts, three-phase.
2. Amperes, three-phase.
3. Kilowatts.
4. Kilowatt hours.
5. Power factor.
6. Frequency.
7. kW Demand with programmable period intervals.
8. kVA.
9. kVAR.
10. **[F: kVARh.]**
11. Harmonics.
12. Voltage Rating: **[H: 95V ac to 135V ac.] [I: 185V ac to 250V ac.]**
13. Manufacturers and Products:
    a. Allen Bradley; Model 1400 Series.
    b. Eaton; **[J: IQ DP-4000] [K:]**.

2.03 ANALOG METERS AND INSTRUMENTS

A. General:

1. Semi-flush mounted, switchboard type.
2. Suitable for mounting on hinged steel panels.
3. Case: Dust-tight, enclosed, with dull black finish.
4. Shape: Square or rectangular.
5. Complete with resistors, reactors, and necessary auxiliaries.
6. 1 percent accuracy.
7. Antiparallax scales with convex clear glass shadow-proof covers for indicating meters and relays.
8. White dials with black points and markings.
9. Indicating Scale: 250-degree circular, nominal.
10. Zero Adjustment: External zero capability.

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B. Instrument and Control Switches:

1. Type: Rotary, cam-operated, with two contacts per stage.
2. Silver contacts and maintained positive contact position.
3. Wiping action closing contacts.
4. Adjacent contacts separated by barriers.
5. Contact assembly enclosed in removable cover.
6. Rating: Minimum 20 amperes with 600-volt insulation.
7. Marked escutcheon plates.
8. Operating Handles:
    a. Power Circuit Breaker Control: Pistol grip.
    b. Instrument Switches: Round knurled handles.
    c. Voltmeter Switches: Four-position, phase-to-phase voltage, and OFF.
    d. Ammeter Switches: Four-position, three-phase currents, and OFF.
    e. Transfer and Auxiliary Switches: Oval type with arrow.
9. Circuit Breaker Switches:
    a. Momentary contact, spring-return type.
    b. Operation indicator to show last operation.
    c. Indicating Lights:
        1) Red to indicate closing.
        2) Green to indicate open.
        3) White to indicate tripped.
        4) Switchboard type with series resistors.
    d. Mechanical key interlock for locking in OFF position.
10. Test Switches for Instrument and Current Sources:
    a. Back connected with clear plastic covers.
    b. Test jacks in phases for current test switches.
    c. Four-pole units for both current and voltage.

C. Indicating Instruments and Meters:

1. Register Size: 6.9-inch scale length, 250-degree arc.
2. ac Voltmeters:
    a. Full-scale rating 150-volt movement calibrated for 15,000 volts, 60-Hz.
    b. Taut-suspension type.
3. ac Ammeters:
    a. Full-scale rating 5-ampere movement.
    b. Taut-suspension type.
4. Wattmeters and Varmeters:
    a. Rated 5 amperes at 120 volts.
    b. Taut-suspension type with built-in watt and var transducer.
    c. Register: Clock.
    d. Elements: Two.

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2.04 INSTRUMENT TRANSFORMERS

A. Current Transformer (CT), 600 Volts and Below:

1. Type: Molded bar or donut.
2. Accuracy: 0.3 at burden imposed by meters and instruments.
3. Shorting type terminal boards for current transformer leads.

B. Potential Transformer (PT), 600 Volts and Below:

1. Type: Molded.
2. Accuracy Classification: 0.3 at burden imposed by meters and instruments, including future.
3. Primary Fuses: Two, current-limiting.
4. Secondary Fuses: One, current-limiting.

C. Current Transformer (CT), Over 600 Volts:

1. Type:
   a. Insulated dry indoor.
   b. Window type for relaying and ground sensing.
   c. Wound type for metering.
2. Transformer Accuracy: In accordance with IEEE C57.13.
3. Class C20 or greater for relaying.
4. Class 1.2 maximum for imposed burden for metering.
5. Rating: As indicated.
6. Mechanical Rating: Equal to interrupting rating of circuit breakers.
7. Thermal Rating: 100 times normal, 1 second.
8. Size to operate continuously at rated primary current without insulation damage.
9. Identify polarity with standard mark or symbol.
10. Secondary Wiring: Install in conduit, PVC tubing or wiring trough.
11. Isolate from adjacent components and circuits by removable insulating or metal barriers.
12. Window type CTs accessible for replacement without removing high voltage insulated connections.

D. Potential Transformer (PT), Over 600 Volts:

1. Type: Insulated dry, indoor.
2. Rating: **[A: 2,400] [B: 4,200] [C: 4,800] [D: 7,200] [E: 8,400] [F: 12,000] [G: 14,400]**/120-volt, single-phase with **[H: 60] [I: 75] [J: 110]** kV BIL rating.
3. **[K: One] [L: Two] [M: Three]** transformers connected **[N: phase-to-ground] [O: phase-to-phase]**.
4. Thermal Capacity: Minimum 55 degrees rise above 30 degrees C ambient.

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5. Mechanical Rating: Equal to short-time current carrying capability of circuit breaker.
6. Accuracy classification in accordance with IEEE C57.13 for connected burden.
7. Primary Protection: Two, integral mounted current-limiting fuses.
8. Secondary Protection: Single, separately mounted current-limiting fuse.
9. Identify polarity with standard marking or symbols.
10. **[P: Mount on drawout carriage installed in metering module, complete with secondary wiring.]**
11. **[Q: Primary and secondary terminals to be disconnected and primary fuses grounded when rollout carriage is in open position.]**

2.05 TEST SWITCH MODULE

A. Function: Multipole switch bank for instrument transformer testing.

1. Allows current injection for each phase.
2. CT inputs short when current switches are open.
3. Ability to visually isolate (open) trip relay output circuits.
4. Cover provided.

B. Manufacturers and Products:

1. ABB; Type FT-1 Flexitest.
2. GE; Multilin 515.

PART 3 EXECUTION

3.01 INSTALLATION

A. In accordance with manufacturer's written instructions.

B. As defined in Section 26 08 00, Commissioning of Electrical Systems.

3.02 MANUFACTURER'S SERVICES

A. Manufacturer's Representative: Present at distribution equipment factory, Site, and classroom designated by Owner, for the minimum person-days listed below, travel time excluded:

1. 2 person-days to enter, confirm, and assist in testing protective relay settings and communications configuration at the distribution equipment. Device settings to be based on values generated in the device coordination study.
2. 2 person-days for initial energization and start-up of distribution system equipment.

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3. 2 person-days for post-startup training of Owner's personnel. Training shall not commence until an accepted detailed lesson plan for each training activity has been reviewed by the Engineer.

B. See Section 01 43 33, Manufacturers' Field Services, and Section 01 91 14, Equipment Testing and Facility Startup.

END OF SECTION

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SECTION 26 12 02
LIQUID-FILLED MEDIUM-VOLTAGE TRANSFORMERS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
   a. 386, Standard for Separable Insulated Connector Systems for Power Distribution Systems Above 600V.
   b. C57.12.00, Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers.
   c. C57.12.22, Pad-Mounted, Compartmental-Type, Self-Cooled, Three-Phase Distribution Transformers with High-Voltage Bushings, 2,500 kVA and Smaller.
   d. C57.12.26, Pad-Mounted, Compartmental-Type, Self-Cooled, Three-Phase Distribution Transformers for Use with Separable Insulated High Voltage Connectors.
   e. C57.12.28, Switchgear and Transformers—Pad-Mounted Equipment, Enclosure Integrity.
   f. C57.12.90, Standard Test Code for Liquid Immersed Distribution, Power, and Regulating Transformers.
   g. C57.106, Guide for Acceptance and Maintenance of Insulating Oil in Equipment.
   h. C62.11, Metal-Oxide Surge Arrestors for Alternating-Current Power Circuits (>1 kV).
2. National Electrical Manufacturers Association (NEMA):
   a. TR 1, Transformers, Regulators, Reactors.
   b. TP 1, Guide for Determining Energy Efficiency for Distribution Transformers.
3. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
4. Underwriters Laboratories Inc. (UL).

1.02 SUBMITTALS

A. Action Submittals:

1. Descriptive information.
2. Dimensional drawings.
3. Transformer nameplate data.
4. Schematic and connection diagrams.

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5. Seismic anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.

B. Informational Submittals:

1. Seismic anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Component and attachment testing seismic certificate of compliance as required by Section 01 45 33, Special Inspection Observation, and Testing.
3. Operation and Maintenance Data: As specified in Section 01 78 23, Operation and Maintenance Data.
4. Factory test reports.

1.03 QUALITY ASSURANCE

A. Design, test, and assemble in accordance with applicable standards of NEMA TR 1, IEEE C57.12.00, IEEE C57.12.22, IEEE C57.12.26, and IEEE C57.12.90.

1.04 EXTRA MATERIALS

A. Furnish, tag, and box for shipment and storage the following materials:

1. One quart of paint to match color and quality of equipment final shop finish.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. ABB.

B. Eaton.

C. General Electric.

2.02 GENERAL

A. Integral Unit: Compartmental type unit consisting of transformer, oil-filled tank, and high and low voltage terminating compartments, assembled on a common structural base.

B. Anchor Bolts: **[A: Galvanized,] [B: Type 316 stainless steel,] [C: sized by equipment manufacturer,] [D: 1/2-inch minimum diameter,]** and as specified in Section 05 50 00, Metal Fabrications.

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2.03 TRANSFORMER

A. kVA Rating As shown.

B. Temperature Rise: **[A: 65] [B: 55/65]** degrees C above 30 degrees average ambient with maximum ambient not to exceed 40 degrees C.

C. Cooling: Self-cooled/fan-cooled, KNAN/KNAF.

1. Increased the allowable full-load self-cooled kVA by 15 percent on units with self-cooled ratings 225 through 2000 kVA and by 25 percent on units with higher self-cooled ratings.

D. Primary Voltage: 24.9 kV line-to-line, volts, three-phase, three-wire, 60-Hz.

1. Two 2-1/2 percent full-capacity taps above and below nominal primary voltage. Externally-operated, padlockable tap changer adjustable only with transformer de-energized.

E. Secondary Voltage: 480/277 volts, three-phase, four-wire, 60 Hz.

F. BIL Rating:

1. 125 kV insulation class transformers.
2. 30 BIL for secondary.

G. Impedance: 5.75 percent nominal.

H. Efficiency: Meet or exceed values in Table 4-1 of NEMA TP 1.

I. Dielectric Coolant: Fully biodegradable, nontoxic, and nonbio-accumulating fluid, qualifying as “less flammable” per NEC 450.23; Factory Mutual Approved or UL Classified.

J. Primary Taps:

1. Full capacity, two 2-1/2 percent below and two 2-1/2 percent above, rated voltage.
2. Externally operated no-load tap changer.
3. Provisions for locking handle in any position.

K. Coil Conductors: Copper or Aluminum windings.

L. Core: Three-legged.

M. Sound Level: In accordance with manufacturer’s standards.

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2.04 TANK, COVER, RADIATORS AND BASE

A. Designed to withstand 7-psig pressure per IEEE and NEMA standards.

B. Welded tank cover, with nonorganic gasket between the cover and the tank.

C. Provide handhole with bolted-gasketed cover on top of tank.

D. Welded radiators.

E. Base to allow jacking, rolling or skidding. Provide jacking pads flush to enclosure and four lifting lugs.

F. Finish: Manufacturer's standard, ANSI 61 or 70, light gray.

2.05 TERMINAL COMPARTMENTS

A. General: IEEE C57.12.28, enclosed high and low voltage compartments at opposite ends of the transformer, bolted to transformer tank.

1. Primary (medium-voltage) Terminal Compartments:
   a. Air-filled compartment sized to accommodate the bottom entry of two 6-inch conduits, each having three 4/0 AWG 25 kV cables and one 4/0 AWG grounding conductor. Provide cable support channels near bottom of terminal chamber.
   b. Surge arresters.
   c. Bushings:
      1) Porcelain or cast resin epoxy, with tin- or silver-plated copper two-hole blade terminals, externally-clamped and front-removable.
      2) Rated for 200 A continuous, 150kV BIL.
      3) Located above bottom of transformer at elevation approximately 50 percent of overall height of unit for units with air-filled terminal chambers.
2. Secondary (low-voltage) Terminal Compartments:
   a. Air-filled compartment sized to accommodate the bottom entry of twelve 4-inch conduits, each having three 500 kcmil 600V cables and one 4/0 AWG grounded conductor. Provide compression lugs suitable for copper conductors. Provide cable support channels near bottom of terminal chamber.
   b. Bushings:
      1) Porcelain or cast resin epoxy, with tin- or silver-plated copper 8-hole spade-type terminals,
      2) Rated for 150 percent of the transformer fan-cooled current, minimum, 600V, 30kV BIL.

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3) Internally connected neutral extending to neutral bushing.
4) Bushings located above bottom of transformer at elevation approximately 50 percent of overall height of unit for units with air-filled terminal chambers.

3. Tin or silver-plated copper bus bars.
4. Doors:
   a. Individual, full-height, air-filled.
   b. Low voltage door: Three-point latching mechanism, vault type handle, door stops and padlocking provision.
   c. High voltage door: Bolted.
5. Grounding pad.
6. Stainless steel equipment nameplate.
7. **[E: Mounting provision for current and potential transformers.]**
8. **[F: Busway opening.]**
9. Nameplate.

2.06 SURGE ARRESTORS

A. Metal-Oxide, Varistor Type:

1. Insulated body, elbow type, 18 kV in accordance with IEEE C62.11.
2. Installed in high voltage compartment.
3. Connected to transformer high voltage terminals.

2.07 TANK GROUNDING PADS

A. High and Low Voltage Compartments: Low voltage neutral connected to externally mounted insulating bushing in low voltage compartment and grounded to tank with removable strap.

2.08 TAP CHANGER WARNING SIGN

A. Red laminated plastic, engraved to white core.

B. Engrave to read: DO NOT OPERATE WHEN TRANSFORMER IS ENERGIZED.

C. Mount above tap changer handle.

2.09 ACCESSORIES

A. Transformer control cabinet:

1. Wall-mounted junction box, NEMA Type 4 to include:
   a. Winding temperature monitor.
   b. Cooling fan starters and controls.

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c. Accessory sensor switch terminals.
d. Thermostatically-controlled anti-corrosion strip heater.
1) Heater power source: 120V, 15A, provided by others.

B. Fan Cooling Equipment:

1. Provide fans, control and power wiring, controller with hand-off-auto switch, in the transformer control cabinet.
2. Provide three-phase winding temperature monitor with contacts to control fans and alarm contacts.
3. Terminate power and control connections for fans in NEMA 4 terminal junction box. Provide Class B stranded Type SIS control and power conductors.
4. Provide hand-off-auto switch with the following functions:
a. Hand: Fans operate continuously.
b. Off: Fans do not operate.
c. Auto: Fans operate from temperature monitor.
5. Fan Power Source: 120V, single phase, 20A provided by others for fans.

C. Nameplates:

1. Provide stainless steel diagrammatic nameplate mounted to each unit per ANSI requirements.
2. Provide white phenolic nameplate engraved to black core indicating transformer equipment number per drawings. Make characters 1 inch tall minimum.

D. Liquid level gauge with Form C alarm contacts wired to terminal blocks in the transformer control cabinet.

E. Dial-type temperature gauge with Form C alarm contacts wired to terminal blocks in the transformer control cabinet.

F. Pressure-vacuum gauge.

G. Cover-mounted pressure-relief device.

H. 1-inch upper filter press and filling plug.

I. Lower drain valve with sampling tap.

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2.10 FACTORY TESTS

A. Production tests in accordance with IEEE C57.12.90 and IEEE C57.12.00, Section 8 and Table 16.

B. Dielectric test in accordance with IEEE C57.12.26.

PART 3 EXECUTION

3.01 GENERAL

A. Secure to mounting pads with anchor bolts.

B. Install plumb and longitudinally in alignment with pad or adjacent building wall.

C. Ground neutrals and enclosures in accordance with applicable codes.

3.02 ADJUSTMENTS

A. Adjust voltage taps to obtain rated output voltage under normal operating load conditions.

END OF SECTION

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SECTION 26 13 13
MEDIUM-VOLTAGE CIRCUIT BREAKER SWITCHGEAR

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
   a. 1115, Recommended Practice for Sizing Nickel-Cadmium Batteries for Stationary Applications, 2014.
   b. C37.04, Standard Rating Structure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis.
   c. C37.06, AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis Preferred Ratings and Related Required Capabilities.
   d. C37.09, Standard Test Procedure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis.
   e. C37.20.2, Metal-Clad and Station Type Cubicle Switchgear.
   f. C57.13, Standard Requirements for Instrument Transformers.
   g. C62.11, Metal-Oxide Surge Arrestors for Alternating Current Power Circuits (>1KV).
2. National Electrical Manufacturers Association (NEMA):
   a. LA 1, Surge Arrestors.
   b. SG 4, Alternating-Current High-Voltage Circuit Breakers.
   c. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
3. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).

1.02 SUBMITTALS

A. Action Submittals:

1. Descriptive product information.
2. Dimensional drawings.
3. Itemized bill of material.
4. Operational description.
5. Installation instructions.
6. One-line, three-line, and control schematic drawings.
7. Connection and interconnection drawings.
8. Conduit entrance locations.
9. Anchoring instructions and details.

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10. Seismic anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.

B. Informational Submittals:

1. Seismic anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Component and attachment testing seismic certificate of compliance as required by Section 01 45 33, Special Inspection, Observation, and Testing.
3. Operation and Maintenance Data: As specified in Section 01 78 23, Operation and Maintenance Data.
4. Certified factory test reports.

1.03 QUALITY ASSURANCE

A. Authority Having Jurisdiction (AHJ):

1. Provide the Work in accordance with NFPA 70, National Electrical Code (NEC). Where required by the AHJ, material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ in order to provide a basis for approval under NEC.
2. Materials and equipment manufactured within the scope of standards published by Underwriters Laboratories, Inc. shall conform to those standards and shall have an applied UL listing mark.

B. UL listing mark for Category A enclosure requirements of IEEE C37.20.2, Appendix A.

1.04 PACKING AND SHIPPING

A. Shipping Splits: None.

1.05 EXTRA MATERIALS

A. Furnish, tag, and box for shipment and storage the following spare parts, special tools, and materials:

1. **[A: 2 Each-Spare fuse, both power and control, of every size and type used.]**
2. **[G: 2 Each-Breaker test cabinet for facilitation of operation of a circuit breaker out of its cubicle for test purposes.]**

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PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Eaton VacClad-W.

B. Powell Industries PowlVac.

C. Schneider Electric (Square D).

D. Siemens.

2.02 GENERAL

A. Furnish switchgear that is the product of a single manufacturer. Assembled units with component parts of several manufacturers will not be acceptable with the exception that such minor items as terminal blocks, test switches, fuses, wiring, etc., may be manufactured by others.

B. Design, test, and assemble in accordance with IEEE C37.04, IEEE C37.06, and IEEE C37.20.2, and NEMA SG4.

C. Suitable for 38 kV maximum, three-phase, solidly-grounded electrical service having an available short-circuit current at line terminals as shown.

D. Rated at 150 kV BIL.

E. Operating Conditions:

1. Ambient Temperature: Maximum 50 degrees C.
2. Site Elevation: 6600 feet above mean sea level.

F. Equipment and devices weighing in excess of 100 pounds shall have lifting lugs.

2.03 STATIONARY STRUCTURE

A. Type: Walk-in outdoor switchgear consisting of breaker, transition, and auxiliary sections assembled to form a rigid, self-supporting, metal enclosed structure.

B. Material: 11-gauge minimum cold-rolled steel, formed with reinforced steel members.

C. Grounded metal barriers between each breaker, main bus, branch cabling, and instrumentation/control.

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D. Breaker compartments to have blocking devices to prevent installation of breaker with lower ampacity or interrupting capacity into compartment designed for a higher rated breaker.

E. Each breaker compartment shall contain:

1. Housing for vacuum circuit breakers.
2. Manually operated drawout mechanism with automatic shutters and safety interlocks.
3. Hinged front panel.
4. Primary and secondary disconnect devices.
5. Control circuit cutout devices.
6. Main bus with connections.
7. Extended ground bus.
8. Terminal block, small wiring, control bus, and cable supports.

F. Each auxiliary compartment shall contain:

1. Front Panel: Hinged.
2. Main bus and connections.
3. Extended ground bus.
4. Drawout potential transformers and associated primary fuses.
5. Relays, meters, and instrumentation.
6. Terminal block, small wiring, control bus, and cable supports.

G. Rear accessible cable compartments shall contain:

1. Provisions for cable entry from bottom.
2. Insulated bushings for primary disconnecting devices.
3. Ground bus extending full width of switchgear.
4. Clamp type cable lugs for 25 kV conductors.

H. Main bus compartment, rear accessible via removal of interior steel barriers, shall contain:

1. Insulated bus and support system.
2. Primary disconnects.
3. Provision for mounting current transformers.

I. Bus transition sections shall be isolated from main bus section.

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2.04 ENCLOSURE

A. Walk-In Outdoor Enclosure:

1. Weather-resistant enclosure with single aisle construction.
2. Hinged, gasketed, full height doors with three-point latch operated by vault type handle with multiple padlocking provisions for each rear switchgear section.
3. Minimum 72-inch-wide aisle in front of switchgear.
4. Access Door: With panic hardware at each end of aisle.
5. Latch Mechanism: Inside quick-release, to allow opening of door from inside even when locked on outside.
6. Gasketed doors, rear panels, end panels, and sloped roof having 4-inch minimum overhang on all sides.
7. Steel bottom enclosure and support assembly undercoated with a coal-tar emulsion.
8. Ventilating louvers with filters in rear panels and at end of each aisle.
9. Lighting: Linear LED 30-foot-candle minimum aisle lights, three-way light switches and minimum of two convenience receptacles in aisle.
10. Space Heaters: Thermostatically controlled 250 watt, 120-volt, in each switchgear vertical section in accordance with UL 1025.
11. Adjustable thermostat for temperature range of 50 degrees F to 70 degrees F.

B. Enclosure Panelboard: Low-voltage panelboard section enclosed in a NEMA 250, Type 1 enclosure.

1. Panelboard:
   a. Full short-circuit current rated in accordance with UL 489.
   b. Thermal magnetic, quick-make, quick-break, indicating type, noninterchangeable, molded case circuit breaker.
   c. Number and breaker ampere ratings as required to serve:
      1) Interior and exterior lighting.
      2) Interior and exterior receptacles.
      3) Switchgear space heaters.

2.05 BUS BARS AND INTERCONNECTIONS

A. Continuous Current Rating: 1,200 amperes with sufficient cross-section to limit temperature rise at rated current to 55 degrees C.

B. Phase Arrangement: Phases A-B-C, left-to-right, top-to-bottom, and front-to-rear as viewed from switchgear front.

C. Buses sized for present and anticipated future loads as indicated on one-line diagram.

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D. Main Bus:

1. Totally enclosed by metal plates.
2. Material: Bar, rounded edge, flat tin- or silver-plated copper.
3. Braced and supported on high dielectric BIL-rated porcelain or glass polyester flame-retardant and track-resistant insulators.
4. Insulate with molded epoxy, applied by fluidized bed process.

E. Ground Bus:

1. Material: Same as main bus.
2. Current Rating: 33 percent of main bus rating.
3. Length: Extend entire width of switchgear.
4. Bolted to ground contact in each breaker compartment and auxiliary section.
5. Pads or terminals at each end for connection to site grounding electrode system as shown.

F. Control Bus:

1. 600-volt insulated copper conductors.
2. Maximum current rating determined by application.
3. Extend from control power source to terminal boards in each unit of grouped lineup.

G. Potential Bus:

1. 600-volt insulated copper conductors.
2. Maximum current rating determined by application.
3. Connected to terminal boards mounted inside enclosure.

H. Bus Bar Connections:

1. Material:
   a. Joints, Splice Plates, and Bar Ends: Tin- or silver-plated copper.
2. Bolts: Steel, with Belleville washers for joints, splice plates, and connections.
3. Insulate bolted connections with preformed, molded, polyvinyl boots held in place with nylon hardware.

2.06 CIRCUIT BREAKERS

A. Type: Vacuum. Interrupter equipped with contact erosion indicators.

B. Rating: 38 kV, 60-Hz.

C. Continuous Current Rating: 1,200 amperes.

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D. Interrupting Rating: 16 kA Interrupting Time: Three cycles.

E. Drawout Type Breaker:

1. Three-pole, single-throw.
2. Electrically charged.
3. Mechanically and electrically trip-free.
4. Position indicator.
5. Operational counter.
6. Auxiliary switches.
7. Primary and secondary devices.
8. Breaker Operation: 48-volt dc close and trip.
    a. Control voltage to be provided from battery system located in a separate building.
9. Primary Contacts:
    a. Breaker mounted stud.
    b. Stationary sockets.
    c. Silver-plated pressure line contacts.
    d. Nonmagnetic, corrosion-resistant leaf springs.
10. Secondary Contacts:
    a. Breaker mounted multiple plug coupler.
    b. Stationary receptacles.
    c. Silver-to-silver contacts.
11. Auxiliary Contacts:
    a. Rated 5 amperes, 120 volts, ac.
    b. Four Type “a” contact to indicate CLOSED position.
    c. Two Type “b” contacts to indicate OPEN position and trip operation.
    d. Provide space for four additional Type a-b contacts.
12. Contacts closing speed independent of control voltage and operator.
13. Mechanically interlock to prevent breaker movement to or from operating position when primary contacts are engaged.

2.07 CURRENT TRANSFORMER (CT)

A. Types:

1. Insulated dry indoor.
2. Window type.

B. Transformer accuracy in accordance with IEEE C57.13: Class C20 or greater for relaying.

C. Rating: **[A: 5] [B: 8] [C: 15]** kV.

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D. Mechanical Rating: Equal to short-time current carrying capability of circuit breakers.

E. Thermal Rating: Maximum 55 degrees rise above 30 degrees C ambient.

F. Size to operate continuously at rated primary current without insulation damage.

G. Identify polarity with standard mark or symbol.

H. Secondary Wiring: Install in **[D: wiring trough]**.

I. Isolate from adjacent components and circuits by removable insulating or metal barriers.

J. Window type CTs accessible for replacement without removing high voltage insulated connections.

2.08 TERMINAL BLOCKS

A. Rating: 600 volts, 30-ampere minimum.

B. Type:

1. One-piece barrier with strap screws.
2. Shorting type for current transformer leads.
3. Pull-apart control wiring terminal boards on drawout units.

C. Provide for:

1. Conductors connecting to circuits external to switchgear.
2. Internal circuits crossing shipping splits.
3. Equipment parts requiring replacement and maintenance.

D. Spares: Minimum 20 percent spare unused terminals.

E. Grouped together terminal blocks for external circuit wiring leads.

F. 6-inch minimum space between columns of terminal blocks.

G. Permanently identify each terminal and columns of terminal blocks.

H. Manufacturer and Product: G.E.; Type EB-5.

2.09 CONTROL WIRING

A. NFPA 70, Type SIS, single-conductor, Class B, stranded copper, rated 600 volts for control, instrumentation, and power circuits.

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B. Individual seven-strand, copper conductors, twisted and covered with a 100 percent aluminum, polyester shield with tinned copper drain wire and overall outer jacket, rated 600 volts, 90 degrees C minimum for transducer output and analog circuits.

C. Conductor Lugs: Preinsulated, self-locking, spade type with reinforced sleeves.

D. Wire Markers: Each wire individually identified with permanent markers at each end.

E. Internal circuit wiring crossing shipping splits to have plug connectors.

F. Splices: Not permitted.

2.10 METERS AND INSTRUMENTS

A. As specified in Section 26 09 13, Power Measurement and Control.

2.11 BATTERY CONTROL SYSTEM

A. Furnished by switchgear manufacturer and remotely installed.

B. Battery:

1. Cell type: Lead-acid, vented.
2. System nominal voltage: 48 volts.
3. Capacity:
    a. Calculate in accordance with IEEE 1115-2014.
        1) Design margin: 15 percent.
        2) Aging factor: 1.25.
        3) Loads:
            a) Circuit breaker control system:
                (1) Pilot lights.
                (2) Protective relay (assume SEL-787).
        4) Load profile:
            a) At t=0, circuit breaker trips.
            b) At t=1 minute, circuit breaker closes.
            c) At t=3 minutes, circuit breaker opens.
            d) At t=5760 minutes, circuit breaker closes.
4. Container: Plastic.
5. Terminal connection hardware: Stainless steel hex-head bolts.
6. Interunit connections: Lead-plated copper.
7. Ship with electrolyte in fully-charged cells.

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C. Battery accessories:

1. Portable hydrometer.
2. Vent hole thermometer.

D. Battery cabinet:

1. Include battery rack and charger.
2. Absorbent pads in bottom of cabinet.
3. Enclosure: NEMA Type 1.
4. Maximum dimensions: 4 feet wide, 2 feet deep.

E. Battery charger:

1. Type: Industrial float, constant voltage.
2. Input: 120V, single phase.
3. Automatically control charging rates.
4. Circuitry: Solid state.
5. AC input circuit breaker.
6. DC output circuit breaker.
7. DC output current and voltage meters or display.
8. "ON" indicating light: Green, LED.
9. Zero to 72-hour manual equalize time.
10. Adjustable float, equalize and current-limit.
11. Alarm relays:
    a. AC power failure.
    b. DC ground.
    c. High or low dc voltage.

2.12 SURGE PROTECTION

A. In accordance with IEEE C62.11 and NEMA LA 1.

B. Connect to line side of main power circuit breakers and ground to switchgear ground bus.

C. Class: **[A: Station.] [B: Intermediate.] [C: Distribution.]**

D. Rating: 18 kV.

2.13 ALTERNATING CURRENT DISTRIBUTION PANEL

A. Rating: **[A: 100] [B:]** amperes, 240/120 volts, single-phase, 60-Hz, complete with solid neutral.

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B. Branch Circuit Breakers:

1. Thermo-magnetic, quick-make, quick-break.
2. ON, TRIPPED, and OFF indicating handle.
3. Amperage: **[A: 15.] [B: 20.]**
4. Interrupting Rating: 10,000 rms symmetrical amperes.

C. **[A: Main circuit breaker rated at ___] [B: Main lugs only rated at ___]** amperes.

D. Enclosure: NEMA 250, Type 1, for **[A: wall] [B: switchgear auxiliary section]** mounting.

E. Circuit directory holder inside door surface.

2.14 ACCESSORIES

A. One each, motorized remote-operated racking system.

B. One each, manual racking crank.

C. One each, manual spring charging crank.

D. One each, spanner nut wrench for main contact removal or replacement.

E. One set, test plugs, cables, and jumper for drawout relays, meters, and electrically operated circuit breakers.

F. **[A: One each, drawout, [B: electric] [C: manual] ground and test device.]**

G. **[A: One each, [B: Wall] [C: Switchgear] mounted circuit breaker test cabinet.]**

H. One each, maintenance slow close lever.

I. Breaker Handling Equipment:

1. One each, portable transfer truck with manual lifting mechanism and yoke.
2. One each, portable turning dolly with manual lifting mechanism and yoke.
3. One each, top rail mounted traveling lifter with manual lifting mechanism and yoke.

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2.15 EQUIPMENT IDENTIFICATION

A. Master Nameplate:

1. Deep etched aluminum with manufacturer's name and model number.
2. Riveted to main vertical section.

B. Section Identification:

1. **[A: Stamped] [B: Engraved]** metallic, riveted to each vertical section.
2. Serial number, bus rating, and section reference number.
3. Size: **[C: Manufacturer's standard.] [D: 6 inches by 2 inches.]**

C. Nameplate:

1. Engraved, **[A: acrylic] [B: phenolic]** for each circuit breaker cubicle and door mounted device.
2. **[C: Black with white] [D: White with black]** block type characters.
3. Character Height: **[E: 3/16] [F: 1/4]** inch.
4. Size: **[G: Manufacturer's standard.] [H: As required for three lines, with 15 characters each line.] [I: .]**
5. Inscriptions: As shown on one-line diagram.
6. Blank plates for future spaces.
7. Attachment Screws: **[J: Self-tapping.] [K: Stainless steel panhead.]**

D. Cubicle Labels:

1. Nonmetallic, applied inside each cubicle compartment.
2. Device serial number, rating, and description.

E. Metering Instruments: Meter type identified on meter face below pointer or dial.

F. Control Switches: Deep etched, aluminum escutcheon plate.

G. Relays and Devices:

1. Stamped metallic, riveted to instrument case.
2. Manufacturer's name, model number, relay type, and rating data.

H. Switchgear Signs:

1. Two signs each on front and back of switchgear.
2. Size: **[A: Manufacturer's standard.] [B: 8 inches by 4 inches, with three lines each.]**
3. Engraved, **[C: acrylic.] [D: phenolic.]**
4. Color: **[E: Red with white.] [F: Orange with black.]**

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5. Inscription: DANGER/HIGH VOLTAGE/KEEP OUT.
6. Characters: Gothic type, **[G: 1] [H: 2] [I:]** inches high.
7. Attachment: Four rivets each sign.

2.16 FACTORY TESTING

A. Switchgear assembly production tested in accordance with IEEE C37.20.2.

B. Circuit breakers production tested in accordance with IEEE C37.09.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install equipment in accordance with manufacturer's instructions and recommendations.

B. Secure equipment to floor with anchor bolts of sufficient size and number adequate for specified seismic conditions.

C. Install equipment plumb and in longitudinal alignment with wall.

D. Tighten current-carrying bolted bus connections and enclosure framing and panel bolts to manufacturer's recommendations.

E. Coordinate terminal connections with installation of secondary feeders.

3.02 MANUFACTURER'S SERVICES

A. Manufacturer's Representative: Present at Site or classroom designated by CH2M for minimum person-days listed below, travel time excluded:

1. Three person-days for installation assistance and inspection.
2. Two person-days for functional testing and completion of Manufacturer's Certificate of Proper Installation.
3. One person-day for pre-startup classroom or Site training.
4. One person-day for post-startup training of operating personnel. Training shall not commence until an accepted detailed lesson plan for each training activity has been reviewed by CH2M.

B. See Section 01 43 33, Manufacturers' Field Services and Section 01 91 14, Equipment Testing and Facility Startup.

END OF SECTION

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SECTION 26 14 13
SWITCHBOARDS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. National Electrical Manufacturers Association (NEMA):
   a. PB 2, Deadfront Distribution Switchboards.
   b. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
2. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
3. Underwriters Laboratories (UL):
   a. 489, Standard for Safety for Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures.
   b. 891, Standard for Safety for Switchboards.
   c. 1561, Standard for Safety for Dry-Type General Purpose and Power Transformers.

1.02 SUBMITTALS

A. Action Submittals:

1. Descriptive product information.
2. Itemized Bill of Material.
3. Dimensional drawings.
4. Operational description.
5. One-line, three-line, and control schematic drawings.
6. Connection and interconnection drawings.
7. Bus data.
8. Incoming line section equipment data.
9. Transformer section equipment data.
10. Conduit entrance locations.
11. Anchoring instructions and details.
12. Seismic anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.

B. Informational Submittals:

1. Seismic anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Manufacturer’s installation instructions.
3. Certified Factory Test Report.

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4. Component and attachment testing seismic certificate of compliance as required by Section 01 45 33, Special Inspection, Observation, and Testing.
5. Operation and Maintenance Data: As specified in Section 01 78 23, Operation and Maintenance Data.
6. Manufacturer's Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers' Field Services.

1.03 QUALITY ASSURANCE

A. Authority Having Jurisdiction (AHJ):

1. Provide the Work in accordance with NFPA 70, National Electrical Code (NEC). Where required by the AHJ, material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ in order to provide a basis for approval under NEC.
2. Materials and equipment manufactured within scope of standards published by Underwriters Laboratories, Inc. shall conform to those standards and shall have an applied UL listing mark.

PART 2 PRODUCTS

2.01 SWITCHBOARDS

A. Manufacturers:

1. Eaton Pow-R-Line *i*.
2. General Electric AV-3.
3. Schneider Electric (Square D) QED-2.

B. Description: Dead front, completely metal enclosed, self-supporting sections bolted together to form one rigid switchboard assembly capable of being moved into position and bolted directly to the floor without use of floor sills.

C. Short Circuit Rating (SCCR): Integrated equipment rating at the indicated RMS symmetrical three-phase fault current and no less than the indicated available fault current.

D. Standards: Comply with NEMA PB 2 and UL 891.

E. Lifting Lugs: Provide on all equipment and devices over 100 pounds.

F. Finishes: Manufacturer's standard baked enamel applied over rust-inhibiting phosphate base coating; plate any unpainted metal for corrosion resistance.

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G. Enclosure: NEMA 250 Type 1, front access with sections aligned across the back to permit placement flush against wall.

H. Externally Mounted Equipment: TVSS, branch circuit and appliance panelboards, distribution power transformers, and automatic transfer switches are not included in this section and are to be separately furnished and mounted.

I. Buswork: Tin- or silver-plated copper throughout entire length with maximum 55 degrees C temperature rise at rated current.

1. Provide non-tapered horizontal bus.
2. Connections and joints are to be bolted with Belleville washers.
3. Insulate phase bus on line side of main protective device(s).
4. Provide 500A minimum horizontal ground bus bolted to each section.
5. Make provisions for future extension as indicated.
6. Provide current transformer provisions as indicated; such as, for utility revenue metering, energy monitoring systems, active harmonic filters.

J. Circuit Breakers:

1. Main Protective Devices: None. Close-couple the switchboard to the low-voltage switchgear.
2. Feeder Protective Devices: Individually mounted.
3. Terminal Ratings: Suitable for use with 75 degrees C wire without derating.
4. Short Circuit Ratings: Fully rated main and branch feeder.
5. Frame Sizes Less Than 250A: Molded case thermal magnetic.
6. Frame Sizes Greater Than 250A and Not Greater than 400A: Molded case; solid-state trip unit with adjustable settings for short-time delay and trip, instantaneous trip, and ground fault delay and trip (LSIG) and zone-selective interlock.
    a. Solid-State Trip Units: Self-powered, automatic rms sensing micro-electronic processor with no external relays or accessories required for basic functions.
7. Handle Padlock Provisions: Provide for all breakers.
8. Breaker Accessories: Provide auxiliary switch, alarm switch, integral metering, etc., as indicated.

K. Identification: In addition to manufacturer’s standard nameplates and code-required notices provide black engraved plates for each breaker inscribed in white 3/8-inch letters with load tag number and description of load served. For outdoor switchboard provide permanent large signs in safety colors inscribed DANGER/HIGH VOLTAGE/KEEP OUT.

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L. Control Wiring:

1. Provide splice-free NEC Type SIS, single-conductor, Class B, stranded copper, rated 600 volts.
2. Conductor Terminations: Pre-insulated, self-locking, spade-type, with reinforced sleeves, with permanent, individual wire markers at each end.
3. Terminal Blocks: Rated 600V, 30A minimum, one-piece barrier type with strap screws, shorting-type for current transformer leads; similar to General Electric Type EB-5. Provide for connection of circuits external to switchboard and internal circuits crossing shipping splits. Permanently identify each terminal and column of terminal blocks.

M. Factory Testing: Perform in accordance with NEMA AB1 and NEMA PB2 and manufacturer's standards.

PART 3 EXECUTION

3.01 MANUFACTURER'S SERVICES

A. Furnish manufacturer's representative for the following services at jobsite or classroom as directed by D/B Contractor for minimum 1 person-day total on site for each switchboard, travel time excluded. Expected activities as listed below:

1. Installation assistance and inspection of installation.
2. Setting of breakers and initial energization of equipment.
3. Project startup and user training.

END OF SECTION

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SECTION 26 20 00
LOW-VOLTAGE AC INDUCTION MOTORS

PART 1 GENERAL

1.01 RELATED SECTIONS

A. This section applies only when referenced by a motor-driven equipment specification. Application, horsepower, enclosure type, mounting, shaft type, synchronous speed, and deviations from this section will be listed in the equipment specification. Where such deviations occur, they shall take precedence over this section.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Bearing Manufacturers Association (ABMA):
   a. 9, Load Ratings and Fatigue Life for Ball Bearings.
   b. 11, Load Ratings and Fatigue Life for Roller Bearings.
2. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
   a. 112, Standard Test Procedure for Polyphase Induction Motors and Generators.
   b. 620, Guide for the Presentation of Thermal Limit Curves for Squirrel Cage Induction Machines.
   c. 841, Standard for Petroleum and Chemical Industry—Premium Efficiency Severe Duty Totally Enclosed Fan-Cooled (TEFC) Squirrel Cage Induction Motors—Up to and Including 370 kW (500 hp).
3. National Electrical Manufacturers Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
   b. C50.41, Polyphase Induction Motors for Power Generating Stations.
   c. MG 1, Motors and Generators.
4. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
5. Underwriters Laboratories (UL):
   a. 83, Standard for Safety for Thermoplastic-Insulated Wire and Cables.
   b. 674, Standard for Safety for Electric Motors and Generators for Use in Division 1 Hazardous (Classified) Locations.
   c. 2111, Standard for Safety for Overheating Protection for Motors.

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1.03 DEFINITIONS

A. CISD-TEFC: Chemical industry, severe-duty enclosure.

B. DIP: Dust-ignition-proof enclosure.

C. EXP: Explosion-proof enclosure.

D. Inverter Duty Motor: Motor meeting applicable requirements of NEMA MG 1, Section IV, Parts 30 and 31.

E. Motor Nameplate Horsepower: That rating after any derating required to allow for extra heating caused by the harmonic content in the voltage applied to the motor by its controller.

F. ODP: Open drip-proof enclosure.

G. TEFC: Totally enclosed, fan-cooled enclosure.

H. TENV: Totally enclosed, nonventilated enclosure.

I. WPI: Open weather protected enclosure, Type I.

J. WPII: Open weather protected enclosure, Type II.

1.04 SUBMITTALS

A. Action Submittals:

1. Descriptive information.
2. Nameplate data in accordance with NEMA MG 1.
3. Additional Rating Information:
    a. Service factor.
    b. Locked rotor current.
    c. No load current.
    d. Adjustable frequency drive motor load classification (for example, variable torque) and minimum allowable motor speed for that load classification.
    e. Guaranteed minimum full load efficiency and power factor.
4. Enclosure type and mounting (such as, horizontal, vertical).
5. Dimensions and total weight.
6. Conduit box dimensions and usable volume as defined in NEMA MG 1 and NFPA 70.
7. Bearing type.
8. Bearing lubrication.
9. Bearing life.
10. Space heater voltage and watts.

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11. Description, ratings, and wiring diagram of motor thermal protection.
12. Motor sound power level in accordance with NEMA MG 1.
13. Maximum brake horsepower required by the equipment driven by the motor.
14. Description and rating of submersible motor moisture sensing system.
15. Anchorage and bracing data sheets and drawings as required by Section 01 88 15, Anchorage and Bracing.

B. Informational Submittals:

1. Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Factory test reports.
3. Component and attachment testing seismic certificate of compliance as required by Section 01 45 33, Special Inspection, Observation, and Testing.
4. Operation and Maintenance Data: As specified in Section 01 78 23, Operation and Maintenance Data.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Materials, equipment, and accessories specified in this section shall be products of:

1. ABB (ABB, Baldor, Reliance).
2. General Electric.
3. U.S. Electrical Motors.
4. TECO-Westinghouse Motor Co.
5. Toshiba International Corp., Industrial Division.
6. WEG Electric Motors Corp.

2.02 GENERAL

A. For multiple units of the same type of equipment, furnish identical motors and accessories of a single manufacturer.

B. In order to obtain single source responsibility, use a single supplier to provide drive motor, its driven equipment, and specified motor accessories.

C. Meet requirements of NEMA MG 1.

D. Motors shall be specifically designed for the use and conditions intended, with a NEMA design letter classification to fit the application.

E. Lifting lugs on motors weighing 100 pounds or more.

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F. Operating Conditions:

1. Maximum ambient temperature not greater than 40 degrees C.
2. Site Elevation: 6,600 feet above sea level.
3. Motors shall be suitable for operating conditions without reduction being required in nameplate rated horsepower or exceeding rated temperature rise.

2.03 HORSEPOWER RATING

A. As designated in motor-driven equipment specification.

B. Constant Speed Applications: Brake horsepower of driven equipment at any operating condition not to exceed motor nameplate horsepower rating, excluding service factor.

C. Adjustable Frequency and Adjustable Speed Applications (Inverter Duty Motor): Driven equipment brake horsepower at any operating condition not to exceed motor nameplate horsepower rating, excluding service factor.

2.04 SERVICE FACTOR

A. Inverter-duty Motors: 1.0 at rated ambient temperature, unless otherwise noted.

B. Other Motors: 1.15 minimum at rated ambient temperature, unless otherwise noted.

2.05 VOLTAGE AND FREQUENCY RATING

A. System Frequency: 60 Hz.

B. Voltage Rating: Unless otherwise indicated in motor-driven equipment specification:

Voltage Rating		
Size	**Voltage**	**Phase**
1/2 hp and smaller	115	1
3/4 hp through 400 hp	460	3
450 hp and larger	4,000	3

C. Suitable for full voltage starting.

D. Suitable for accelerating the connected load with supply voltage at motor starter supply terminals dipping to 90 percent of motor rated voltage.

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2.06 EFFICIENCY AND POWER FACTOR

A. For all motors except single-phase, under 1 hp, multispeed, short-time rated and submersible motors, or motors driving gates, valves, elevators, cranes, trolleys, and hoists:

1. Efficiency:
   a. Tested in accordance with NEMA MG 1, Paragraph 12.59.
   b. Guaranteed minimum at full load in accordance with NEMA MG 1 Table 12-12, Full-load Efficiencies for NEMA Premium Efficiency Electric Motors Rated 600 Volts or Less (Random Wound), or as indicated in motor-driven equipment specification.
2. Power Factor: Guaranteed minimum at full load shall be manufacturer's standard or as indicated in motor-driven equipment specification.

2.07 LOCKED ROTOR RATINGS

A. Locked rotor kVA Code F or lower, if motor horsepower not covered by NEMA MG 1 tables.

B. Safe Stall Time: 12 seconds or greater.

2.08 INSULATION SYSTEMS

A. Single-Phase, Fractional Horsepower Motors: Manufacturer's standard winding insulation system.

B. Motors Rated Over 600 Volts: Sealed windings in accordance with NEMA MG 1.

C. Three-phase and Integral Horsepower Motors: Unless otherwise indicated in motor-driven equipment specification, Class F at nameplate horsepower and designated operating conditions.

2.09 ENCLOSURES

A. Enclosures to conform to NEMA MG 1.

B. TEFC and TENV: Furnish with drain hole with porous drain/weather plug.

C. Submersible: In accordance with Article Special Motors.

D. Chemical Industry, Severe-Duty (CISD-TEFC): In accordance with Article Special Motors.

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2.10 TERMINAL (CONDUIT) BOXES

A. Diagonally split, rotatable to each of four 90-degree positions. Threaded hubs for conduit attachment.

B. Except ODP, furnish gaskets between box halves and between box and motor frame.

C. Terminal for connection of equipment grounding wire in each terminal box.

D. Coordinate motor terminal box conduit entries versus size and quantity of conduits shown on Drawings.

2.11 BEARINGS AND LUBRICATION

A. Horizontal Motors:

1. 3/4 hp and Smaller: Permanently lubricated and sealed ball bearings, or regreasable ball bearings in labyrinth sealed end bells with removable grease relief plugs.
2. 1 hp through 400 hp: Regreasable ball bearings in labyrinth sealed end bells with removable grease relief plugs.
3. Minimum 100,000 hours L-10 bearing life for ball and roller bearings as defined in ABMA 9 and ABMA 11.

B. Vertical Motors:

1. Thrust Bearings:
   a. Antifriction bearing.
   b. Manufacturer’s standard lubrication.
   c. Oil lubricated 125 hp and larger.
   d. Minimum 50,000 hours L-10 bearing life.
2. Guide Bearings:
   a. Manufacturer’s standard bearing type.
   b. Manufacturer’s standard lubrication.
   c. Minimum 100,000 hours L-10 bearing life.

C. Regreasable Antifriction Bearings:

1. Readily accessible, grease injection fittings.
2. Readily accessible, removable grease relief plugs.

D. Oil Lubrication Systems:

1. Oil reservoirs with sight level gauge.
2. Oil fill and drain openings with opening plugs.
3. Provisions for necessary oil circulation and cooling.

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E. Inverter Duty Rated Motors,

1. Shaft Grounding: Motors larger than 25 hp shall have shaft grounding rings on the driven end (DE) shaft.
2. Bearing Isolation: Motors larger than 50 hp shall have electrically isolated bearings to prevent stray current damage.

2.12 NOISE

A. Measured in accordance with NEMA MG 1.

B. Motors controlled by adjustable frequency drive systems shall not exceed sound levels of 3 dBA higher than NEMA MG 1.

2.13 BALANCE AND VIBRATION CONTROL

A. In accordance with NEMA MG 1, Part 7.

2.14 EQUIPMENT FINISH

A. Protect Motor for Service Conditions:

1. ODP Enclosures: Indoor industrial atmospheres.
2. Other Enclosures: Outdoor industrial atmospheres, including moisture and direct sunlight exposure.

B. Internal Finish: Bore and end turns coated with clear polyester or epoxy varnish.

2.15 SPECIAL FEATURES AND ACCESSORIES

A. Screen Over Air Openings: **[A: Corrosion-resistant] [B: Stainless steel]** on motors with ODP, WPI, and WPII enclosures meeting requirements for guarded machine in NEMA MG 1, and attached with stainless steel screws.

B. Winding Thermal Protection:

1. Thermostats:
   a. Motors for adjustable speed application: 50 hp and larger.
   b. Bi-metal disk or rod type thermostats embedded in stator windings.
   c. Automatic reset contacts rated 120 volts ac, 5 amps minimum, opening on excessive temperature. (Provide manual reset at motor controller.)
   d. Leads extending to separate terminal box for motors 100 hp and larger.

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C. Space Heaters:

1. Where indicated on the driven equipment motor data sheets: Provide winding space heaters with leads wired out to separate condulet or terminal box.
2. Provide extra hole or hub on motor terminal box as required.
3. Unless shown otherwise, heater shall be suitable for 120V ac supply, with wattage suitable for motor frame size.

D. Nameplates:

1. Raised or stamped letters on stainless steel or aluminum.
2. Display motor data required by NEMA MG 1, Paragraph 10.39 and Paragraph 10.40 in addition to bearing numbers for both bearings.
3. Premium efficiency motor nameplates to display NEMA nominal efficiency, guaranteed minimum efficiency, full load power factor, and maximum allowable kVAR for power factor correction capacitors.

E. Anchor Bolts: Provide meeting manufacturer's recommendations and of sufficient size and number for specified seismic condition.

2.16 SPECIAL MOTORS

A. Requirements in this article take precedence over conflicting features specified elsewhere in this section.

B. Chemical Industry, Severe-Duty (CISD-TEFC):

1. In accordance with IEEE 841.
2. TEFC in accordance with NEMA MG 1.
3. Suitable for indoor or outdoor installation in severe-duty applications including high humidity, chemical (corrosive), dirty, or salty atmospheres.
4. Motor Frame, End Shields, Terminal Box, and Fan Cover: Cast iron.
5. Ventilating Fan: Corrosion-resistant, nonsparking, external.
6. Drain and Breather Fittings: Stainless steel.
7. Nameplate: Stainless steel.
8. Gaskets between terminal box halves and terminal box and motor frame.
9. Extra slinger on rotor shaft to prevent moisture seepage along shaft into motor.
10. Double shielded bearings.
11. 125,000 hours minimum L-10 bearing life for direct-connected loads.
12. External Finish: Double-coated epoxy enamel.
13. Coated rotor and stator air gap surfaces.
14. Insulation System, Windings, and Connections:
    a. Class F insulation, Class B rise or better at 1.0 service factor.
    b. Multiple dips and bakes of nonhygroscopic polyester varnish.

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15. Service Factor:
    a. At 40 Degrees C Ambient: 1.15.
    b. At 65 Degrees C Ambient: 1.00.
16. Safe Stall Time Without Injurious Heating: 20 seconds minimum.

C. Inverter Duty Motor:

1. Motor supplied power by adjustable voltage and adjustable frequency drives shall be inverter duty rated.
2. Suitable for operation over entire speed range indicated.
3. Provide forced ventilation where speed ratio is greater than published range for motor provided.
4. Shaft Grounding Device: Motors larger than **[B: 20] [C:]** hp shall be provided with shaft grounding brush or conductive micro fiber shaft grounding ring. Shaft grounding device shall be solidly bonded to grounded motor frame per manufacturer's recommendations.
    a. Manufacturers:
        1) Grounding Brush: Sohre Turbomachinery, Inc.
        2) Grounding Ring: EST-Aegis.

D. Submersible Pump Motor:

1. Manufacturers:
    a. Reliance Electric.
    b. ITT Flygt Corp.
2. At 100 Percent Load:

Submersible Pump Motors		
Horsepower	**Guaranteed Minimum Efficiency**	**Guaranteed Minimum Power Factor**
5 through 10	80	82
10.1 through 50	85	82
50.1 through 100	87	82
Over 100	89	82

3. Insulation System: Manufacturer's standard Class B or Class F.
4. Motor capable of running dry continuously.
5. Enclosure:
    a. Hermetically sealed, watertight, for continuous submergence up to 65-foot depth.
    b. Listed to meet UL 674 and NFPA 70 requirements for Class I, Division 1, Group D hazardous atmosphere.
    c. Seals: Tandem mechanical.

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6. Bearing and Lubrication:
    a. Permanently sealed and lubricated, replaceable antifriction guide and thrust bearings.
    b. Minimum 15,000 hours L-10 bearing life.
7. Inrush kVA/horsepower no greater than NEMA MG 1 and NFPA 70, Code F.
8. Winding Thermal Protection:
    a. Thermal sensor and switch assembly, one each phase, embedded in stator windings and wired in series.
    b. Switches normally closed, open upon excessive winding temperature, and automatically reclose when temperature has cooled to safe operating level.
    c. Switch contacts rated at 5 amps, 120V ac.
9. Motor Seal Failure Moisture Detection:
    a. Probes or sensors to detect moisture beyond seals.
    b. Probe or sensor monitoring module for mounting in motor controller, suitable for operation from 120V ac supply.
    c. Monitoring module with control power transformer, probe test switch and test light, and two independent 120V ac contacts, one opening and one closing when flux of moisture is detected.
10. Bearing Overtemperature Protection for Motors Larger than 100 hp:
    a. Sensor on lower bearing housing monitoring bearing temperature.
    b. Any monitoring relay necessary to provide 120V ac contact opening on bearing overtemperature.
11. Winding thermal protection, moisture detection, and bearing overtemperature specified above may be monitored by single device providing two independent 120V ac contacts, one closing and one opening on malfunction.
12. Connecting Cables:
    a. Each cable suitable for hard service, submersible duty with watertight seal where cable enters motor.
    b. Length: **[C: 30] [D:]** feet minimum.
    c. UL 83 listed and sized in accordance with NFPA 70.

2.17 FACTORY TESTING

A. Tests:

1. In accordance with IEEE 112 for polyphase motors.
2. Routine (production) tests in accordance with NEMA MG 1. Test multispeed motors at all speeds.
3. For energy efficient motors, test efficiency and power factor at 50 percent, 75 percent, and 100 percent of rated horsepower:
    a. In accordance with IEEE 112, Test Method B, and NEMA MG 1, Paragraph 12.59. and Paragraph 12.60.

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b. For motors 500 hp and larger where facilities are not available to test by dynamometer (Test Method B), determine efficiency by IEEE 112, Test Method F.
c. On motors of 100 hp and smaller, furnish certified copy of motor efficiency test report on an identical motor.

4. Provide certified test reports for polyphase motors 100 hp and larger.

B. Test Report Forms:

1. Routine Tests: IEEE 112, Form A-1.

PART 3 EXECUTION

3.01 INSTALLATION

A. In accordance with manufacturer's instructions and recommendations.

B. Align motor carefully and properly with driven equipment.

C. Secure equipment to mounting surface with anchor bolts.

END OF SECTION

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SECTION 26 22 00
LOW-VOLTAGE TRANSFORMERS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Code of Federal Regulations (CFR): 10 CFR Part 431, DOE 2016 efficiency.
2. Institute of Electrical and Electronics Engineers (IEEE): C57.96, Guide for Loading Dry Type Transformers.
3. National Electrical Contractor's Association (NECA): 409, Recommended Practice for Installing and Maintaining Dry-Type Transformers.
4. National Electrical Manufacturers Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
   b. ST 20, Dry-Type Transformers for General Applications.
5. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
6. Underwriters Laboratories, Inc. (UL):
   a. 486E, Standard for Equipment Wiring Terminals for use with Aluminum and/or Copper Conductors.
   b. 489, Standard for Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures.
   c. 1561, Standard for Dry-Type, General Purpose, and Power Transformers.

1.02 SUBMITTALS

A. Action Submittals:

1. Dimensions and weight.
2. Transformer nameplate data, including efficiency.
3. Anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.

B. Informational Submittals:

1. Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Component and attachment testing seismic certificate of compliance as required by Section 01 45 33, Special Inspection, Observation, and Testing.

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PART 2 PRODUCTS

2.01 GENERAL

A. UL 1561, NEMA ST 20, unless otherwise indicated.

B. Dry-type, self-cooled, two-winding, with copper windings.

C. Units larger than 5 kVA suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.

D. Efficiency: Meet or exceed DOE 2016 efficiency requirements. Maximum Sound Level per NEMA ST 20

E. Overload capability: Short-term overload per IEEE C57.96.

F. Wall Bracket: For single-phase units, 15 kVA to 37-1/2 kVA, and for three-phase units, 15 kVA to 30 kVA.

G. Vibration Isolators:

1. Rated for transformer's weight.
2. Isolation Efficiency: 99 percent, at fundamental frequency of sound emitted by transformer.
3. Less Than 30 kVA: Isolate entire unit from structure with external vibration isolators.
4. 30 kVA and Above: Isolate core and coil assembly from transformer enclosure with integral vibration isolator.

H. Manufacturers:

1. Eaton.
2. General Electric Co.
3. Schneider Electric (Square D).

2.02 MINI-POWER CENTER (MPC)

A. General: Transformer, primary, and secondary main circuit breakers, and secondary panelboard section enclosed in NEMA 250, Type 1, 3R or 3R stainless steel enclosure as indicated on the panelboard schedule.

B. Transformer:

1. Insulation Class and Temperature Rise: Manufacturer's standard.
2. Efficiency: Manufacturer's standard (DOE 2016 efficiency).
3. Core and Coil: Encapsulated.
4. Full capacity, 5 percent voltage taps, two below normal voltage.

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C. Panelboard: Full, UL 489, short-circuit current rated.

1. Type: Thermal-magnetic, quick-make, quick-break, indicating, with noninterchangeable molded case circuit breakers.
2. Number and Breaker Ampere Ratings: Refer to Panelboard Schedule.

2.03 GENERAL PURPOSE TRANSFORMER

A. Insulation Class and Temperature Rise: Manufacturer’s standard.

B. Core and Coil:

1. Encapsulated for single-phase units 1/2 kVA to 25 kVA and for three-phase units 3 kVA to 15 kVA.
2. Thermosetting varnish impregnated for single-phase units 37.5 kVA and above, and for three-phase units 30 kVA and above.

C. Enclosure:

1. Single-Phase, 3 kVA to 25 kVA: NEMA 250, Type 3R, nonventilated.
2. Single-Phase, 37-1/2 kVA and Above: NEMA 250, Type 2, ventilated.
3. Three-Phase, 3 kVA to 15 kVA: NEMA 250, Type 3R, nonventilated.
4. Three-Phase, 30 kVA and Above: NEMA 250, Type 2, ventilated.
5. Outdoor Locations: NEMA 250, Type 3R.
6. Corrosive Locations: NEMA 250, Type 3R stainless steel.

D. Voltage Taps: Four 2-1/2 percent, full capacity; two above and two below normal voltage rating.

2.04 K-RATED TRANSFORMER

A. Insulation Class and Temperature Rise: Manufacturer’s standard.

B. Core and Coil: Sized and configured to reduce overheating caused by harmonic components.

C. Enclosure: NEMA 250, Type 2 with weather shield for NEMA 3R rating.

D. Voltage Taps: Six 2.5 percent, full capacity; two above and four below normal voltage rating.

E. K Factor: K-13.

F. Neutral Bus and Terminal: 200 percent of rated current.

G. Electrostatic shield.

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PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with NECA and manufacturer's instructions.

B. Load external vibration isolator such that no direct transformer unit metal is in direct contact with mounting surface.

C. Provide moisture-proof, flexible conduit for electrical connections.

D. Connect voltage taps to achieve (approximately) rated output voltage under normal plant load conditions.

E. Provide wall brackets for single-phase units, 15 kVA to 167-1/2 kVA, and three-phase units, 15 kVA to 30 kVA, where indicated.

END OF SECTION

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SECTION 26 23 00
LOW-VOLTAGE SWITCHGEAR

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American National Standards Institute (ANSI): C37.50, Switchgear—Low-Voltage AC Power Circuit Breakers Used in Enclosures—Test Procedures.
2. Institute of Electrical and Electronics Engineers (IEEE):
   a. C37.13, Standard for Low-Voltage AC Power Circuit Breakers Used in Enclosures.
   b. C37.16, Standard for Preferred Ratings, Related Requirements, and Application Recommendation for Low-Voltage AC (635V and below) and DC (3200V and below) Power Circuit Breakers.
   c. C37.20.1, Standard for Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear.
   d. C37.20.3, Standard for Metal Enclosed Interrupter Switchgear.
   e. C37.100, Standard Definitions for Power Switchgear.
3. National Electrical Manufacturers Association (NEMA): 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
4. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
5. Underwriters Laboratories, Inc. (UL):
   a. 489, Standard for Safety for Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit-Breaker Enclosures.
   b. 1558, Standard for Safety for Metal-Enclosed, Low-Voltage Power Circuit Breaker Switchgear.

1.02 SUBMITTALS

A. Action Submittals:

1. Conduit entrance locations.
2. Protective device data including time-current characteristics.
3. Shipping splits.
4. Field wiring and connection diagrams.
5. One-line diagrams.
6. Control schematic drawings.
7. Connection and interconnection drawings.
8. Incoming line section data.
9. Seismic anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.

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B. Informational Submittals:

1. Seismic anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Manufacturer's installation instructions.
3. Factory Test Report.
4. Component and attachment testing seismic certificate of compliance as required by Section 01 45 33, Special Inspection, Observation, and Testing.
5. Operation and Maintenance Data: As specified in Section 01 78 23, Operation and Maintenance Data.
6. Manufacturer's Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers' Field Services.

1.03 QUALITY ASSURANCE

A. Authority Having Jurisdiction (AHJ):

1. Provide the Work in accordance with NFPA 70, National Electrical Code (NEC). Where required by the AHJ, material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ in order to provide a basis for approval under NEC.
2. Materials and equipment manufactured within the scope of standards published by Underwriters Laboratories, Inc. shall conform to those standards and shall have an applied UL listing mark.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Materials, equipment, and accessories specified in this section shall be products of:

1. Eaton Magnum DS.
2. General Electric AKD-20.
3. Schneider Electric (Square D) PowerZone 4.

2.02 GENERAL REQUIREMENTS

A. Service: 480Y volts, three-phase, three-wire solidly grounded wye having an available short circuit current at line terminals as shown.

B. Standards: Comply with IEEE C37.20.3, IEEE C37.100, and IEEE C37.50, and UL 1558.

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C. Description: IEEE C37.50 construction, consisting of pull, metering, breaker, transition, and auxiliary sections assembled to form a rigid, self-supporting, metal enclosed structure.

D. Short Circuit Rating (SCCR): Integrated equipment rating at the indicated RMS symmetrical three-phase fault current.

E. Lifting Lugs: Provide on all equipment and devices over 100 pounds.

F. Terminal Ratings: Suitable for use with 75 degrees C wire without derating.

G. Structures, General:

1. Cold-rolled steel, formed with reinforced steel members.
2. Grounded metal barriers between each breaker, main bus, branch cabling, and instrumentation/control.
3. Modular-designed steel frame with removable plates and individual, bolted, steel-framed vertical sections.
4. Individual, hinged doors over each breaker, metering, and auxiliary compartment.
5. Manufacturer's standard baked enamel applied over a rust-inhibiting, phosphate base coating; plate unpainted parts for corrosion resistance.

H. Cable Installation and Termination Compartments: Provide in rear of each vertical section with bolted cover plates and cable supports.

I. Breaker Compartments: Individual grounded compartments as follows:

1. Compartment door is to be padlockable.
2. Provide flame retardant, arc-track-resistant nonmetallic rear barrier.
3. Include draw-out rails, stationary breaker contacts, interlocks, and necessary control and indicating devices.
4. Shutters are to cover all stationary contacts with breaker in either TEST or DISCONNECT position.
5. Padlocking provision on rackout rails are to allow locking breaker in either TEST or DISCONNECT position.
6. Mechanical interlocks are to prevent breaker movement from any position, or when between positions, unless breaker is open.
7. Four Distinct Breaker Positions: CONNECTED, TEST, DISCONNECTED, and WITHDRAW, with position indicators.
8. Draw-out mechanism is to be operable without opening breaker door.
9. Breaker frame grounded to steel frame throughout draw-out travel.
10. Future breaker provision compartments are to be fully equipped with all electrical connections and compartment door, with removable bolted metal barrier across compartment opening.
11. Instrumentation and Control Tray: Where access is required for replacement, maintenance or terminations provide slide-out tray,

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mounted above associated breaker if applicable, for instrumentation and control equipment and devices.

J. Auxiliary and Transition Sections: Equipped with devices as indicated, with hinged door over each compartment.

K. Indoor Enclosure: NEMA 250, Type 1, with formed edges on hinged and nonhinged panels, and full-height bolt-on rear panels for each section.

L. Buswork: Tin- or silver-plated copper throughout entire length with maximum 55 degrees C temperature rise at rated current.

1. Provide non-tapered horizontal bus.
2. Connections and joints are to be bolted with Belleville washers.
3. Insulate phase bus on line side of main protective device(s).
4. Provide 500A minimum horizontal ground bus bolted to each section.
5. Make provisions for future extension as indicated.
6. Provide current transformer provisions as indicated.

M. Circuit Breakers:

1. Type: Draw-out insulated case in compartments as described above, except TVSS, control and convenience power supply breakers may be individually mounted thermal magnetic.
2. Short Circuit Ratings: Fully rated main and branch feeder.
3. Minimum Frame Rating: 800A.
4. Solid-State Trip Units: Self-powered, automatic rms sensing micro-electronic processor with no external relays or accessories required for basic functions.
5. Long Time Short Time Instantaneous Ground Fault (LSIG): Solid-state trip unit as described above plus integral adjustable ground fault delay and trip settings with selectable I^2T. Provide zone-selective interlock system where indicated on the drawings.
6. Current Ratings: Provide UL 489 100 percent rated.
7. Breaker Accessories: Provide shunt trip, under-voltage trip, auxiliary switch, alarm switch, key interlock, integral metering, motor operators, etc., as indicated.

N. Identification: In addition to manufacturer’s standard nameplates and code-required notices provide black engraved plates for each breaker inscribed in white 3/8-inch letters with load tag number and description of load served. For outdoor switchboard provide permanent large signs in safety colors inscribed DANGER/HIGH VOLTAGE/KEEP OUT on both doors, back and front.

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O. Control Wiring:

1. Provide splice-free NEC Type SIS, single-conductor, Class B, stranded copper, rated 600 volts.
2. Conductor Terminations: Pre-insulated, self-locking, spade-type, with reinforced sleeves, with permanent, individual wire markers at each end.
3. Terminal Blocks: Rated 600V, 30A minimum, one-piece barrier type with strap screws, shorting-type for current transformer leads; similar to General Electric Type EB-5. Provide for connection of circuits external to switchboard and internal circuits crossing shipping splits. Permanently identify each terminal and column of terminal blocks.

P. Power Meter: Where indicated provide solid-state device with, direct-voltage input and current input via current transformers, and programmable limits to activate up to four alarms. Metered parameters are to be volts and amperes, true RMS, three-phase and neutral if any, plus kilowatts, kilowatt hours, power factor, and kW demand with programmable period intervals Provide Ethernet communications port for indicated protocol.

Q. Factory Testing: Perform in accordance with IEEE C37.20.3 Metal Enclosed Interrupter Switchgear and manufacturer's standards.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install equipment in accordance with manufacturer's instructions and recommendations.

B. Secure equipment to mounting pads with anchor bolts.

C. Install equipment plumb and in longitudinal alignment with pad or wall.

D. Coordinate terminal connections with installation of secondary feeders.

3.02 MANUFACTURER'S SERVICES

A. Furnish manufacturer's representative in accordance with Section 01 43 33, Manufacturers' Field Services, for the following services at Site or classroom as designated by CH2M for minimum person-days listed below, travel time excluded:

1. 2 person-days for installation assistance and inspection.
2. 2 person-days for functional testing.
3. 1 person-day for prestartup classroom or Site training.
4. 1 person-day for post-startup training.

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B. Furnish startup services and training of **[A: Owner's] [B:]** personnel at such times as requested by CH2M.

C. Provide Manufacturer's Certificate of Proper Installation in accordance with Section 01 43 33, Manufacturers' Services.

END OF SECTION

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SECTION 26 24 16
PANELBOARDS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. National Electrical Contractor's Association (NECA): 407, Recommended Practice for Installing and Maintaining Panelboards.
2. National Electrical Manufacturers Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
   b. 289, Application Guide for Ground Fault Circuit Interrupters.
   c. KS 1, Enclosed Switches.
   d. PB 1, Panelboards.
   e. PB 1.1, General Instructions for Proper Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less.
3. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
4. Underwriters Laboratories, Inc. (UL):
   a. 67, Standard for Panelboards.
   b. 98, Standard for Enclosed and Dead-Front Switches.
   c. 486E, Standard for Equipment Wiring Terminals for use with Aluminum and/or Copper Conductors.
   d. 489, Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures.
   e. 508, Standard for Industrial Control Equipment.
   f. 870, Wireways, Auxiliary Gutters and Associated Fittings.
   g. 943, Ground-Fault Circuit-Interrupters.
   h. 1699, Standard for Arc-Fault Circuit-Interrupters.

1.02 SUBMITTALS

A. Action Submittals:

1. Protective devices with factory settings.
2. Provisions for future protective devices.
3. Space for future protective devices.
4. Voltage, frequency, and phase ratings.
5. Enclosure type.
6. Bus and terminal bar configurations and current ratings.
7. Provisions for circuit terminations with wire range.
8. Short circuit current rating of assembled panelboard at system voltage.

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9. Features, characteristics, ratings, and factory settings of auxiliary components.
    a. Anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.

B. Informational Submittals:

1. Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Manufacturer's recommended installation instructions.
3. Component and attachment testing seismic certificate of compliance as required by Section 01 45 33, Special Inspection, Observation, and Testing.

1.03 QUALITY ASSURANCE

A. Listing and Labeling: Provide products specified in this section that are listed and labeled as defined in NEC Article 100.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Materials, equipment, and accessories specified in this section shall be products of:

1. Eaton.
2. General Electric Co.
3. Schneider Electric (Square D).

2.02 GENERAL

A. Provide low voltage panelboards for application at 600V or less in compliance with NEMA PB 1, NFPA 70, UL 486E, and UL 67.

B. Wire Terminations: Suitable for use with 75 degrees C or greater wire insulation systems at NEC 75 degrees C conductor ampacity without derating.

C. Load Current Ratings: Unless otherwise indicated, load current ratings for panelboard assemblies, including bus and circuit breakers, are noncontinuous as defined by NEC. Continuous ratings shall be 80 percent of noncontinuous rating except where "continuous", "100 percent", etc., is indicated equipment and devices are to be rated for continuous load current at indicated value.

D. Short Circuit Current Rating (SCCR): Integrated equipment short circuit rating for each panelboard assembly is not to be less than the fault current

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available at point of application in distribution system and the scheduled SCCR.

E. Overcurrent Protective Devices: Provide circuit breakers in accordance with NEMA AB 1, NEMA KS 1, UL 98, and UL 489, adapted to panelboard installation such that they may be replaced without disturbing adjacent devices and without removing main bus.

F. Spaces: Provide fully equipped provisions with individual covers for future like devices along full length of bus regardless of number of units and spaces indicated.

G. Series-Connected Short Circuit Ratings: Devices shall be fully rated, except UL 67 listed, series-connected ratings may be applied only where specifically indicated. NEC Article 700 Emergency System devices are to be fully rated.

H. Circuit Breakers Types: Molded case showing ON/OFF and TRIPPED positions of operating handle with trip units as follows:

1. Unless otherwise indicated provide thermal-magnetic; provide single continuous adjustment of instantaneous trip with a minimum range of 3X to 10X for frames greater than 100 amps.
2. AFCI: Arc Fault Circuit Interrupter breaker.
3. GFCI: Ground Fault Circuit Interrupter breaker with UL 943, Class A 5-mA for protection of personnel.
4. EGFI: Equipment Ground Fault Interrupter breaker with ground fault 30-mA ground fault trip and UL listed for protection of equipment.
5. HACR: Heating and Air Conditioning Rated breakers.
6. SWD: Switching Duty rated breakers.
7. LSI: Electronic trip unit with fixed long-time trip, adjustable short-time trip and delay, and adjustable instantaneous trip settings.
8. LSIG: Electronic trip unit as above also with adjustable ground fault trip and delay settings.

I. Bus Connections: Bolted except 225-ampere frame size and greater may be plug-in type where individual positive locking device requires mechanical release for removal.

J. Enclosures: Provide as specified in Section 26 05 02 Basic Electrical Requirements, with manufacturer’s standard gray finish, except NEMA 1 enclosure box may be unfinished galvanized sheet steel.

K. Identification: Provide nameplates as specified in Section 26 05 02 Basic Electrical Requirements. Provide individual nameplates for distribution panelboard branch breakers.

L. Bus: Material: Copper full sized throughout length.

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M. Feeder Lugs: Replaceable, bolted mechanical or crimp compression type.

N. Equipment Ground Terminal Bus: Copper with individual mechanical termination points no less than the quantity of breaker positions plus feeder ground and grounding electrode conductors, with minimum rated ampacity no less than 25 percent phase bus unless otherwise indicated.

O. Neutral Terminal Bus: Copper with individual termination points for each branch position plus feeder neutrals, with rated ampacity same a phase bus unless otherwise indicated.

P. Breaker Locking Provisions: Furnish for handle padlocking of main and feeder breakers; also provide for branch breakers where indicated.

Q. Provide special features where indicated including, but not limited to, the following:

1. Service Equipment Approval: Listed as such.
2. Isolated Equipment Ground Terminal Bar: Additional ground bus as specified above, insulated from box.
3. Controls: UL 508; Class I 120V ac unless otherwise indicated, protected by fuse or circuit breaker.
4. Surge Suppression (TVSS): Comply with Section 26 43 00 Transient Voltage Suppression; include dedicated circuit breaker disconnect.

2.03 LIGHTING AND APPLIANCE BRANCH CIRCUIT PANELBOARDS

A. Multi-Section Panelboards: Provide where more than 42 poles are required or more than one section is otherwise indicated.

1. Provide multiple sections with separate fronts, each individually installed and field interconnected to form a single electrical unit.
2. Recessed-mount panel sections tubs and flush covers to be same size.
3. Surface-mount panel sections may be of unequal heights.
4. Provide feed-through and main lugs in individual sections as required for field assembly of a complete multi-section panelboard.
5. Provide neutral and ground terminal bars in each section.

B. NEMA 250 Type 1 Branch Panelboard Enclosure:

1. Front trim secured to box with concealed trim clamps.
2. Surface-mount front trim to have same dimensions as box.
3. Flush front trims to overlap box nominal 3/4 inch on all sides.
4. Provide door in front trim, with concealed hinges, and multi-point latching if greater than 30 inches high.
5. Door lock to have flush catch and tumbler lock; all panelboards keyed alike, with two milled keys each lock.

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C. Circuit Directory: Metal frame with transparent plastic face and enclosed card, mounted inside each panel door.

D. Special Construction:

1. Where indicated provide column-type configuration with narrow cabinet extended as wireway to overhead junction box equipped with ground and neutral terminal buses.
2. Where indicated provide hinged front cover (Door In Door) with entire front trim hinged with standard door within hinged trim cover.

PART 3 EXECUTION

3.01 GENERAL

A. Install in accordance with NECA 407, NEMA PB 1.1, NEMA 289 and manufacturers' written installation instructions.

B. Install top of cabinet trim 78 inches above floor, unless otherwise noted.

C. Install filler plates in unused spaces.

D. In panel gutters train conductors neatly in groups, bundle, and wrap with nylon wire ties.

E. Except lighting and appliance branch circuit panelboards with doors, provide engraved circuit identification for each breaker.

3.02 LIGHTING AND APPLIANCE BRANCH CIRCUIT PANELBOARD

A. Mount flush panels uniformly flush with wall finish; remove flush covers for painting of adjacent wall surfaces.

B. Provide typewritten circuit directory for each panelboard.

C. Run separate conduits for feeder and branch circuit wiring between multi-section panelboard sections. Branch circuit conduit is to be two trade sizes larger than required for installed branch circuit wires, 1-1/4-inch minimum.

D. Stub two 1-inch empty conduits from each flush panel section into accessible ceiling space, or space designated to be ceiling space in future, and into raised floor space or to below floor (except at slabs on grade).

END OF SECTION

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SECTION 26 24 19
LOW-VOLTAGE MOTOR CONTROL

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which shall be followed for this section:

1. Institute of Electrical and Electronics Engineers (IEEE): C2, National Electrical Safety Code (NESC).
2. National Electrical Contractors Association (NECA): 402, Standard for Installing and Maintaining Motor Control Centers.
3. National Electrical Manufacturers Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1,000 volts maximum).
   b. ICS 1, Industrial Control and Systems: General Requirements.
   c. ICS 2, Controllers, Contactors, and Overload Relays Rated 600 Volts.
   d. ICS 2.3, Instructions for the Handling, Installation, Operation, and Maintenance of Motor Control Centers Rated Not More Than 600V.
   e. ICS 18, Motor Control Centers.
   f. KS 1, Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum).
4. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
5. Underwriters Laboratories, Inc. (UL):
   a. 98, Enclosed and Dead-Front Switches.
   b. 489, Molded-Case Circuit Breakers, Molded-Case Switches, and Circuit Breaker Enclosures.
   c. 845, Motor Control Centers.

1.02 SUBMITTALS

A. Action Submittals:

1. Tabulation of MCC Units:
   a. Nameplate information including motor (equipment) tag numbers.
   b. Motor horsepower.
   c. Nameplate full load current.
2. Conduit entrance locations.
3. Protective device data.
4. Anchoring instructions and details, and seismic calculations.
5. Shipping splits.
6. Wiring and connection diagrams for each unit with external field wiring interface.

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7. One-line diagrams.
8. Schematic (elementary) diagrams for each unit.
9. Communication protocol, software, and programming information.

B. Informational Submittals:

1. Manufacturer's installation instructions.
2. Factory test reports, certified.
3. Special shipping, storage and protection, and handling instructions.
4. Operation and Maintenance Data.

1.03 QUALITY ASSURANCE

A. Provide products manufactured within scope of Underwriters Laboratories that conform to UL Standards and have applied UL Listing Mark.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Shipping Splits: Established by manufacturer to facilitate ingress of equipment to final installation location within building.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Materials, equipment, and accessories specified in this section shall be products of:

1. Eaton.
2. GE Industrial Systems.
3. Schneider Electric (Square D).

2.02 GENERAL

A. Like Items of Equipment: **[A: End product of one manufacturer] [B: and] [C: same manufacturer as low voltage switchboard and panelboards for standardization]**.

B. Make adjustments necessary to wiring, conduit, disconnect devices, motor starters, branch circuit protection, and other affected material or equipment to accommodate motors actually provided under this Contract.

C. Controllers: NEMA ICS 1, NEMA ICS 2, Class A.

D. Control Transformer:

1. Two winding, 120-volt secondary, primary voltage to suit.
2. Two current-limiting fuses for primary circuit.

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3. One fuse in secondary circuit **[A: with blown fuse indicator]**.
4. Mount within starter unit.

E. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.

F. Lifting lugs on equipment and devices weighing over 100 pounds.

G. Anchor Bolts: **[A: Galvanized,] [B: Type 316 stainless steel,] [C: sized seismically by a licensed structural engineer registered in the State where equipment is to reside,] [D: 1/2-inch minimum diameter,]** and as specified in Section 05 50 00, Metal Fabrications.

H. Seismic Zone and Importance Factor shall be as specified in Section 01 61 00, Common Product Requirements.

I. Operating Conditions:

1. Ambient Temperature: Maximum **[A: 40] [B: 45] [C:]** degrees C **[D: direct sun]**.
2. Altitude: **[E: Zero feet.] [F: above sea level.]**
3. Equipment to be fully rated.

J. Enclosures: In accordance with NEMA 250.

K. Equipment Finish:

1. Electrocoating process applied over rust-inhibiting phosphated base coating.
2. Exterior Color: **[A: Light gray.] [B: Medium gray.] [C: Dark gray.] [D: Manufacturer's standard.]**

2.03 SEPARATELY MOUNTED MOTOR CONTROL

A. Manually Operated Starter, Fractional Horsepower:

1. Rating: 16 amperes continuous at 277 volts maximum.
2. Single-phase, nonreversing, full voltage with overload protection.
3. Toggle operated **[A: , keyed where shown]**.
4. Enclosure: **[B: NEMA 250, Type [C: 1] [D: 3R] [E: 4] [F: 7 and 9]**.**] [G: As shown.]**
5. Neon Light: **[H: Red.] [I: Green.]**
6. Handle guard/lock-off **[J: attachment] [K: plate]**.

B. Manually Operated Starter, Integral Horsepower:

1. Rating: Horsepower rated to maximum of 10 horsepower at 600 volts with overload protection.

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2. Single-phase or three-phase, nonreversing, full voltage.
3. Control: **[A: Toggle] [B: or] [C: pushbutton]**.
4. Enclosure: **[D: NEMA 250, Type [E: 1] [F: 3R] [G: 4] [H: 4X] [I: 7 and 9] [J: 12].] [K: As shown on Drawings.]**
5. **[L: Red pilot light in series with auxiliary contact.]**
6. Locking in OFF position.
7. Two spare auxiliary, field-changeable contacts.

C. Combination Full-Voltage, Magnetic Starter:

1. Rating: Horsepower rated at 600 volts, UL labeled for **[A: 22,000] [B: 65,000] [C: 100,000]** amperes at 480 volts short circuit capacity with overload protection.
2. Three-phase, nonreversing, full voltage.
3. Control: **[D: HAND/OFF/AUTO selector switch.] [E: STOP/START pushbutton.] [F: As shown on Drawings.]**
4. Disconnect Type: **[G: Motor circuit protector.] [H: Circuit breaker.] [I: Current limiting, fused.] [J: Nonfused.]**
5. Enclosure: **[K: NEMA 250, Type [L: 1] [M: 3R] [N: 4] [O: 4X] [P: 7 and 9] [Q: 12].] [R: As shown on Drawings.]**
6. **[S: Pilot Lights: [T: Red–ON] [U: and] [V: Green–OFF].]**
7. Padlockable operating handle, capable of up to three locks.

D. Combination Reduced-Voltage, Magnetic Starter:

1. Rating: Horsepower rated at 600 volts, UL labeled for **[A: 22,000] [B: 65,000] [C: 100,000]** amperes at 480 volts short circuit capacity with overload protection.
2. Three-phase, nonreversing.
3. Control: **[D: HAND/OFF/AUTO selector switch.] [E: STOP/START pushbutton.] [F: As shown on Drawings.]**
4. Disconnect Type **[G: Motor circuit protector.] [H: Circuit breakers.] [I: Current limiting, fused.] [J: Nonfused.]**
5. **[K: Autotransformer with 50, 65, and 80 percent voltage taps and thermal overtemperature protection] [L: Wye-delta]** for closed circuit transition and adjustable time interval between motor starting and running.
6. Enclosure: **[M: NEMA 250, Type [N: 1] [O: 3R] [P: 4] [Q: 4X] [R: 7 and 9] [S: 12].] [T: As shown.]**
7. **[U: Pilot Lights: [V: Red–ON] [W: and] [X: Green–OFF].]**
8. Padlockable operating handle, capable of up to three locks.

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E. Combination Reduced Voltage, Solid State Starter:

1. Rating: Horsepower rated at 600 volts, UL labeled for **[A: 22,000] [B: 65,000] [C: 100,000]** amperes at 480 volts short circuit capacity with overload protection.
2. Three-phase, nonreversing with bypass run contactor.
3. Control: **[D: HAND/OFF/AUTO selector switch.] [E: STOP/START pushbutton.] [F: As shown on Drawings.]**
4. Disconnect Type: **[G: Motor circuit protector.] [H: Circuit breakers.] [I: Current limiting, fused.] [J: Nonfused.]**
5. Class 10/20/30 electronic overload relay, switch, or dip switch selectable.
6. Kick start, with adjustable torque and time settings.
7. Ramp start, selectable current or torque, and adjustable time.
8. Smooth stop ramp, adjustable time.
9. Phase loss unbalance and phase reversal protection.
10. LED display or LCD of fault, N.O. contact to communicate fault conditions.
11. Enclosure: **[K: NEMA 250, Type [L: 1] [M: 3R] [N: 4] [O: 4X] [P: 7 and 9] [Q: 12].] [R: As shown.]**
12. **[S: Pilot Lights: [T: Red–ON] [U: and] [V: Green–OFF].]**
13. Padlockable operating handle, capable of up to three locks.

F. Combination Two-Speed Motor, Magnetic Starter:

1. Rating: Horsepower rated at 600 volts, UL labeled for **[A: 22,000] [B: 65,000] [C: 100,000]** amperes at 480 volts short circuit capacity with overload protection.
2. Three-phase, nonreversing, full voltage.
3. Control: **[D: HAND/OFF/AUTO and LOW/OFF/HIGH selector switches] [E: STOP/HIGH/LOW pushbuttons].] [F: As shown on Drawings.]**
4. Disconnect Type: **[G: Motor circuit protector.] [H: Circuit breaker.] [I: Current-limiting, fused.] [J: Nonfused.]**
5. Suitable for **[K: two-speed, [L: two] [M: single]-winding] [N: four-speed, two winding] [O: variable torque] [P: constant torque] [Q: constant horsepower]** motors.
6. Enclosure: **[R: NEMA 250, Type [S: 1] [T: 3R] [U: 4] [V: 4X] [W: 7 and 9] [X: 12].] [Y: As shown on Drawings.]**
7. Pilot Lights: **[Z: Green–OFF] [Red–HIGH SPEED] [and] [Amber–LOW SPEED].]**
8. Padlockable operating handle, capable of up to three locks.

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G. Combination Reversing, Magnetic Starter:

1. Rating: Horsepower rated at 600 volts, UL labeled for **[A: 22,000] [B: 65,000] [C: 100,000]** amperes at 480 volts short circuit capacity with overload protection.
2. Three-phase, reversing, full voltage.
3. Control: **[D: HAND/OFF/AUTO and FORWARD/REVERSE selector switches.] [E: STOP/FORWARD/REVERSE pushbuttons.] [F: As shown on Drawings.]**
4. Disconnect Type: **[G: Motor circuit protector.] [H: Circuit breaker.] [I: Current-limiting, fused.] [J: Nonfused.]**
5. Suitable for squirrel cage motors.
6. Enclosure: **[K: NEMA 250, Type [L: 1] [M: 3R] [N: 4] [O: 4X] [P: 7 and 9] [Q: 12].] [R: As shown on Drawings.]**
7. Pilot Lights: **[S: Green–OFF,] [T: Red–FORWARD,] [U: Amber-REVERSE]**.**]**.
8. Padlockable operating handle, capable of up to three locks.

H. Full Voltage, Magnetic Starter:

1. Rating: Horsepower rated at 600 volts with overload protection.
2. Three-phase, nonreversing, full voltage.
3. Control: **[A: HAND/OFF/AUTO selector switch.] [B: STOP/START pushbutton.] [C: As shown on Drawings.]**
4. Enclosure: **[D: NEMA 250, Type [E: 1] [F: 3R] [G: 4] [H: 4X] [I: 7 and 9] [J: 12].] [K: As shown on Drawings.]**
5. **[L: Pilot Lights: [M: Red–ON] [N: and] [O: Green–OFF].]**
6. Padlockable operating handle, capable of up to three locks.

I. Reduced Voltage, Magnetic Starter:

1. Rating: Horsepower rated at 600 volts with overload protection.
2. Three-phase, nonreversing.
3. Control: **[A: HAND/OFF/AUTO selector switch.] [B: STOP/START pushbutton.] [C: As shown on Drawings.]**
4. **[D: Autotransfer with 50, 65, and 80 percent voltage taps and thermal overtemperature protection] [E: Wye-delta]** for closed circuit transition and adjustable time interval between motor starting and running.
5. Enclosure: **[F: NEMA 250, Type [G: 1] [H: 3R] [I: 4] [J: 4X] [K: 7 and 9] [L: 12].] [M: As shown on Drawings.]**
6. **[N: Pilot Lights: [O: Red–ON] [P: and] [Q: Green–OFF].]**
7. Padlockable operating handle, capable of up to three locks.

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J. Reduced Voltage, Solid State Starter:

1. Rating: Horsepower rated at 600 volts with overload protection.
2. Three-phase, nonreversing with bypass run contactor.
3. Control: **[A: HAND/OFF/AUTO selector switch.] [B: STOP/START pushbutton.] [C: As shown on Drawings.]**
4. Class 10/20/30 electronic overload relay, switch, or dip switch selectable.
5. Kick start, with adjustable torque and time settings.
6. Ramp start, selectable current or torque, and adjustable time.
7. Smooth stop ramp, adjustable time.
8. Phase loss unbalance and phase reversal protection.
9. LED display or LCD of fault, N.O. contact to communicate fault conditions.
10. Enclosure: **[D: NEMA 250, Type [E: 1] [F: 3R] [G: 4] [H: 4X] [I: 7 and 9] [J: 12].] [K: As shown on Drawings.]**
11. **[L: Pilot Lights: [M: Red–ON] [N: and] [O: Green–OFF].]**
12. Padlockable operating handle, capable of up to three locks.

K. Two-Speed, Magnetic Starter:

1. Rating: Horsepower rated at 600 volts with overload protection.
2. Three-phase, nonreversing, full voltage.
3. Control: **[A: HAND/OFF/AUTO and LOW/HIGH selector switches.] [B: STOP/HIGH/LOW pushbuttons.] [C: As shown on Drawings.]**
4. Suitable for **[D: two-speed, [E: two] [F: single] winding] [G: four-speed, two winding] [H: constant torque] [I: constant horsepower]** motors.
5. Enclosure: **[J: NEMA 250, Type [K: 1] [L: 3R] [M: 4] [N: 4X] [O: 7 and 9] [P: 12].] [Q: As shown on Drawings.]**
6. Pilot Lights: **[R: Green–OFF,] [S: Red–HIGH SPEED,] [T: Amber–LOW SPEED].]**
7. Padlockable operating handle, capable of up to three locks.

L. Reversing, Magnetic Starter:

1. Rating: Horsepower rated at 600 volts, UL labeled with overload protection.
2. Three-phase, reversing, full voltage.
3. Control: **[A: HAND/OFF/AUTO and FORWARD/REVERSE selector switches.] [B: STOP/FORWARD/REVERSE pushbuttons.] [C: As shown on Drawings.]**
4. Suitable for squirrel cage motors.
5. Enclosure: **[D: NEMA 250, Type [E: 1] [F: 3R] [G: 4] [H: 4X] [I: 7 and 9] [J: 12].] [K: As shown on Drawings.]**

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6. Pilot Lights: **[L: Green-OFF,] [M: Red-FORWARD,] [N: Amber-REVERSE].]**
7. Padlockable operating handle, capable of up to three locks.

M. Thermal Motor Overload Protection:

1. Inverse-time-limit characteristic.
2. Heater: Bimetallic overload, adjustable trip, or directly heated melting alloy, ratchet principle type element.
3. Relay Trip: **[A: Quick, Class 10.] [B: Standard, Class 20.] [C: Slow, Class 30.]**
4. Manual reset.
5. Provide in each ungrounded phase.
6. Mount within starter unit.

N. Solid State Motor Overload Protection:

1. Where indicated on the drawings, provide a microprocessor-based overload relay in each starter.
2. Normally-closed fault relay for direct control of the motor controller.
3. Trip on:
   a. Motor overload with inverse time/current characteristics:
      1) Class 10/20/30 relay trip, adjustable.
   b. Power loss.
   c. Unbalanced phase.
4. Provide a door mounted operator interface display for control, programming, monitoring, diagnostic and alarm functions and overload relay reset.
5. Control power for the overload relay will be provided by an external 120V branch circuit.
6. Provide Modbus TCP communication.
7. Provide input and output (I/O) points as needed to support the functions indicated on the drawings. Provide I/O expansion modules as required.

2.04 MOTOR CONTROL CENTERS

A. Manufacturer and Product Line:

1. Eaton, Freedom 2100.
2. General Electric, Evolution 9000 Series.
3. Schneider Electric (Square D), Model 6 iMCC.

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B. General:

1. In accordance with NEMA ICS 1, NEMA ICS 2, NEMA ICS 18, and UL 845.
2. Short Circuit Rating for entire motor control center as a complete assembly.
3. Lifting lugs on all equipment and devices weighing over 100 pounds.

C. Enclosure:

1. Horizontal Wiring Compartments: Accessible from front, full width, top and bottom.
2. Vertical Wiring Compartment: Full height, isolated from unit starters with separate hinged door and tie supports. No terminal blocks allowed in vertical wireway compartment.
3. Unit Compartment: Individual compartments separated by steel barriers for each starter, feeder, or other unit capable of being wired from front without unit removal.
4. Compartment Doors: Separate hinged doors for each starter, feeder, or other unit.
5. Door Interlocking: Mechanically interlock starter and feeder doors so doors cannot be opened with unit energized. Provide defeater mechanism to allow intentional access and energizing at any time by qualified individual.
6. External disconnect handles with ON/OFF and trip positions showing, padlockable in OFF position with up to three-lock capability.

D. Communications:

1. Provide motor control centers with a factory assembled Modbus TCP field bus communications network providing direct connectivity between MCC devices and the system controller and/or HMI.
2. Provide an Ethernet 10/100 auto-negotiate industrial switch per lineup. Provide sufficient ports to connect to each Modbus TCP device and have at least 2 open ports for a customer connection and a PC connection for maintenance.
3. Mount the Ethernet switch in the top removable unit of each vertical section or shipping split and not in the vertical wireway. If required by the application, the switch shall be capable of connecting to multiple sections.
4. Include a complete and factory-tested cabling system. The cabling system shall be Cat 5 and consist of home run connections from each Modbus device to the Ethernet switch. Non-standard, non-shielded cable will not be accepted.

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5. Provide Modbus TCP communications modules at each device interfacing to the Modbus TCP field bus. Install the communications modules in the unit device compartment or bucket.

E. Motor Controller Unit:

1. Construction:
   a. Drawout combination type with stab connections for starters NEMA ICS, Size 5 and smaller.
   b. Bolt-on combination type with cable connection to riser for starters NEMA ICS, Size 6 and larger.
   c. Readily interchangeable with starters of similar size.
   d. Pull-apart unit control wiring terminal boards on drawout units. Minimum Dimensions: 12 inches high by full section width, less vertical wireway.
2. Constant Speed Starters: NEMA ICS 18, standard rating, except none smaller than NEMA ICS, Size 1.
3. Reduced Voltage Starters: Solid state soft starter with running bypass contactor.
4. Adjustable Frequency Drive: Drives as specified in Section 26 29 23, Low-Voltage Adjustable Frequency Drive System.
5. Motor Thermal Protector Interface: Provide solid start motor protection relay.
6. LSI Feeder Circuit Breakers: Where indicated, provide breakers with adjustable short time trip and delay settings and auxiliary power connection to unit control power supply.

F. Main Circuit Breaker Units:

1. Furnish fixed-mounted units where indicated in accordance with NEMA AB 1 and UL 489 and the following specifications.
2. Molded Case Switch:
   a. Where indicated, provide a molded case switch.
3. Static Trip Circuit Breakers (LSI & LSIG):
   a. Where indicated, provide.
   b. Insulated or molded case breakers with ambient insensitive solid-state trips and having current sensors and logic circuits integral in breaker frame.
   c. LSI: Solid-state current control with adjustable long-time ampere setting, adjustable long-time delay, adjustable short-time trip and delay band, fixed or adjustable instantaneous trip.
   d. LSIG: As LSI above with adjustable ground fault trip and delay band.
   e. Locate trip button on front cover of breaker to permit mechanical simulation overcurrent tripping.

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4. Molded Case Circuit Breaker (MCCB): Thermal-magnetic trip with instantaneous trip adjustable 5X to 10X minimum.

G. Feeder Breaker Units:

1. Construction: As specified in Paragraph Motor Controller Unit.
2. Breakers: As specified for main and tie units.

H. MCC Digital Power Meter (DPM):

1. Where indicated furnish microprocessor-based electronic metering package, complete with keypad and CTs.
2. Real Time Displays: Phase current, phase-to-phase and phase-to-neutral voltage, watts, volt amperes, volt-amperes reactive, power factor, frequency, and percent THD.
3. Historical Displays: Minimum and maximum current, voltage, power, volt-amperes, power factor, and frequency. Also display watt-hours, volt-ampere hours, and volt-amperes reactive hours.
4. Control power voltage transformer with disconnect and fuses.
5. Voltage sensing directly from bus with disconnect and fuses.
6. Current transformers with ratio as required, complete with shorting terminal block.
7. Programmable CT and PT Ratios: Accuracy plus or minus 0.3 percent.
8. Communications: Interface capability to computer network as indicated.
9. Provide meters similar to Eaton Cutler-Hammer IQ DP-4000 and General Electric PQM-II.

I. SPDs: As specified in Section 26 43 00, Surge Protective Devices, to be furnished separately and mounted external to MCC with minimum lead length to main feed connection.

J. Control Devices: Pushbuttons, Indicating Lights, Selector Switches: As specified in Section 26 05 04, Basic Electrical Materials and Methods.

K. Nameplates:

1. Laminated plastic; White, engraved to black core.
2. Provide for each motor control center and each unit.
3. Engrave with approved submittal inscription.
4. Provide blank nameplates on provisions for future units.
5. Attach with stainless steel panhead screws on face of control center.

L. Space Heaters: Thermostatically controlled. Locate in bottom of each vertical section for operation from 120-volt power source derived internal to MCC.

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M. Factory Testing:

1. Applicable Standards: NEMA ICS 18, UL 845, and NEC Article 430, Part H.
2. Perform standard factory inspection and tests in accordance with NEMA requirements to verify components have been designed to specification, assembled in accordance with applicable standards, and each unit functions in accordance with electrical diagrams.
3. Perform dielectric tests on primary circuits and equipment, except potential transformers.
    a. Perform continuity checks, energize circuit at rated voltage, and operate control devices, metering and relays to verify correct operation. Actual sequences of operation shall be performed to verify component devices operate correctly in circuits as required.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:

1. Install equipment in accordance with NEMA ICS 2.3, IEEE C2, NECA 402, Submittals, and manufacturer's written instructions and recommendations.
2. Secure equipment to mounting pads with anchor bolts of sufficient size and number adequate for specified seismic conditions.
3. Install equipment plumb and in longitudinal alignment with pad or wall.
4. Coordinate terminal connections with installation of secondary feeders.
5. Grout mounting channels into floor or mounting pads.
6. Retighten current-carrying bolted connections and enclosure support framing and panels to manufacturer's recommendations.
7. Motor Data: Provide typed, self-adhesive label attached inside each motor starter enclosure door displaying the following information:
    a. Motor served by tag number and equipment name.
    b. Nameplate horsepower.
    c. Motor code letter.
    d. Full load amperes.
    e. Service factor.
    f. Installed overload relay heater catalog number.

B. Circuit Breakers:

1. Field adjust trip settings of motor starter magnetic-trip-only circuit breakers.
2. Adjust to approximately 11 times motor rated current.
3. Determine motor rated current from motor nameplate following installation.

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C. Overload Relay: Select and install overload relay heaters and switch settings after actual nameplate full-load current rating of motor has been determined.

3.02 MANUFACTURER'S SERVICES

A. Furnish manufacturer's representative **[A: in accordance with Section 01 43 33, Manufacturers' Field Services,]** for the following services at Job Site or classroom as designated by **[B: Owner,] [C: ,]** for minimum person-days listed below, travel time excluded:

1. **[D:]** person-days for installation assistance, and inspection of installation.
2. **[E:]** person-days for **[F: functional] [G: and] [H: performance]** testing.
3. **[I:]** person-days for plant startup.
4. **[J:]** person-days for training of Owner's personnel.

END OF SECTION

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SECTION 26 27 26
WIRING DEVICES

PART 1 GENERAL (NOT USED)

PART 2 PRODUCTS

2.01 SWITCHES

A. Switch, General Purpose: Industrial-grade quiet tumbler switch with screw terminals, automatic grounding clip and integral grounding terminal, conforming to NEMA WD 1 and FS W-S-896F/GEN.

1. Rating: 20 amps, 120/277 volts.
2. Color: White in finished areas and gray in other areas.
3. Switch with Pilot Light: Lighted toggle.
4. Manufacturers and Product Series:
    a. Arrow Hart 2221.
    b. Bryant 4901.
    c. Hubbell 1222.
    d. Leviton 1221.

B. Switch, Motor Rated, General Purpose: Totally-enclosed snap-action manual motor starting/disconnect switch without overload protection; quick-make, slow-break design with silver alloy contacts and screw-type terminals, UL 508 listed.

1. Ratings: 30 amperes, 600V ac, 2 hp for 120V ac, single-phase, two-pole, and 15 hp for 480V ac, three-phase, three-pole.
2. Manufacturers: Bryant or Hubbell.

C. Switch, Motor Rated, Explosion-Proof: Manual motor starter in required enclosure as specified in Section 26 05 02, Basic Electrical Requirements, with lockable external handle operator.

1. Rating: 10 hp, 480V ac, three-phase, three-pole.
2. Manufacturer and Type: Eaton B101.

2.02 RECEPTACLES

A. General Purpose Duplex: Industrial-grade, two-pole, three-wire grounding type with screw type wire terminals, impact-resistant nylon cover and body, one-piece mounting strap with integral ground contact (rivetless construction), conforming to NEMA WD 1 and FS W-C-596.

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1. Rating and Configuration: 20 amps 125 volts, NEMA 5-20R.
2. Color: White in finished areas and gray in other areas.
3. Manufacturers and Product Series:
    a. Arrow Hart 5362.
    b. Hubbell 5362.
    c. Leviton 5362.
    d. Pass & Seymour 5362.

B. Surge Protective Duplex: Same as general purpose except 15A rated with UL 1449 Listed with minimum surge current ratings of 24 kA line-neutral and 12 kA line-ground for 8/20µs waveform, with EMI/RFI attenuation of 40 dB minimum from 5 kHz to 100 MHz, and with integral LED indicator and audible alarm on failure; Leviton 8280 is typical.

C. Ground Fault Circuit Interrupter Duplex: Same as general purpose except 15A rated with UL Listed 5 mA GFCI, trip indicator and push-to-test button. Provide feed-through connections for downstream protection.

D. Corrosion-Resistant Duplex. Same as general purpose, except with nickel-coated metal parts and yellow color; Pass & Seymour CR6300, Hubbell 53CM62 and Leviton 53CM-62 are typical.

E. Special-Purpose: As indicated and/or to match utilization equipment.

F. Explosion Proof. Dead front, interlocked, circuit breaking, with required enclosure and suitable for hazardous area classification in accordance with Section 26 05 02, Basic Electrical Requirements.

1. Ratings: 20 amps 125V ac unless otherwise indicated.
2. Manufacturers and Product Series:
    a. Crouse-Hinds Ark Guard 2, ENR.
    b. Appleton U-Line.
    c. Killark UGR/UGP.

2.03 DEVICE PLATES

A. Flush Wall for General Purpose Devices: Nylon, color to match device, with oval-head metal mounting screw color-matched to plate.

B. Flush Wall Stainless Steel: Where indicated, and for special purpose receptacles, provide specification-grade, one-piece, 0.040-inch nominal thickness plates of ASTM A167, Type 302/304 stainless steel with smooth satin finish.

C. Device in Cast Metal Box: Malleable ferrous metal on ferrous metal boxes, copper-free aluminum on aluminum boxes, and with gaskets and oval-head stainless steel screws.

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D. Device in Sheet Steel Surface Box: 1/2-inch high zinc- or cadmium-plated steel with oval-head stainless steel screws.

E. Weatherproof: Gasketed die-cast metal, UL listed wet location while in use.

1. Receptacles: Pad-locking provision, in use or not; Thomas & Betts Red-Dot CK-series is typical.
2. Switches: External operator for internal switch as specified; Crouse-Hinds DS-181 or DS-185, or Appleton FSK-1VTS or FSK-1VS.

F. Engraving: 3/16-inch characters with contrasting black or white filler, unless otherwise indicated.

2.04 MULTI-OUTLET SURFACE RACEWAY SYSTEMS

A. Provide devices and plates as specified above with gray Wiremold raceway components as required for complete assembly.

PART 3 EXECUTION

3.01 GENERAL

A. Mounting Heights: See Section 26 05 33, Raceway and Boxes.

B. Install in accordance with manufacturer's instructions.

3.02 SWITCHES

A. Install switches for operation in vertical orientation. Single-pole and two-way switches toggle to be in the up position when the switch is on.

B. Install motor rated switch within sight of motor or motor controller respectively where used as a disconnect switch for motor or motor controller.

3.03 RECEPTACLES

A. Install duplex receptacles with grounding slot down, except where horizontal mounting is required install with neutral slot down.

B. Feed-Through GFCI Duplex: Where GFCI duplex is required outdoors and another duplex receptacle on the same circuit is located in a readily accessible location within 35 circuit-feet, install feed-through model indoors and wire through it to the outdoor duplex for GFCI protection. Mark outdoor receptacle as GFCI protected.

C. Provide matching plugs for special purpose and explosion proof receptacles where required to power project-furnished utilization equipment and where indicated.

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3.04 DEVICE PLATES

A. Securely fasten to wiring device; ensure a tight fit to box.

B. Flush Mounted: Install with all four edges in continuous contact with finished wall surfaces without use of mats or similar materials. Plaster fillings will not be acceptable.

C. Surface Mounted: Plate shall not extend beyond sides of box; where flush-mount plates must be installed on surface box provide box with flat mounting face no less than 1/8 inch greater than plate face dimensions. Install with alignment tolerance to box of 1/16 inch.

D. Weatherproof Receptacles: Install with cover hinge above receptacle opening.

END OF SECTION

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SECTION 26 29 23
LOW-VOLTAGE ADJUSTABLE FREQUENCY DRIVE SYSTEM

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Electronic Industries Alliance (EIA): 359-A-1, Special Colors.
2. Hydraulic Institute Standards (HIS).
3. Institute of Electrical and Electronics Engineers (IEEE):
   a. 112, Standard Test Procedure for Polyphase Induction Motors and Generators.
   b. 519, Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems.
   c. C62.41, Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits.
4. National Electrical Manufacturer's Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
   b. CP 1, Shunt Capacitors.
   c. MG 1, Motors and Generators.
   d. WC 57, Standard for Control, Thermocouple Extensions, and Instrumentation Cables.
5. National Fire Protection Association (NFPA): 79, Electrical Standard for Industrial Machinery.

1.02 SUBMITTALS

A. Action Submittals:

1. Enclosure description including seismic rating.
2. Tabulation of AFD Units:
   a. Unit description with included options.
   b. Nameplate information including:
      1) AFD equipment number (tag number).
      2) Voltage rating.
      3) Carrier frequency range.
      4) Maximum current rating.
      5) Full load heat rejection.
   c. Disconnect and protective device information.
   d. Options.
3. Dimensional drawings and weights.
4. Front and side panel elevations.

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5. Conduit entrance locations.
6. Descriptive literature (catalog cuts) for all control devices including, but not limited to timers, relays, control switches, line and load-side filters, reactors, etc.
7. Field wiring and connection diagrams for each unit with external interface.
8. One-line and three-line diagrams.
9. Schematic (elementary) diagrams for each unit.
10. Communication protocol, software and programming information.
11. Seismic anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.

B. Informational Submittals:

1. Seismic anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Manufacturer's installation instructions.
3. Factory test reports, certified.
4. Special shipping, storage and protection, and handling instructions.
5. Operation and Maintenance Data.

C. Record submittal, revised pre-shipping submittal plus as-built changes: Incorporate as-built changes made by the Electrical Installer.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Components and accessories specified in this section shall be products of:

1. ABB.
2. Eaton.
3. General Electric.
4. Rockwell (Allen-Bradley).
5. Schneider Electric (Square D).

2.02 SUPPLEMENTS

A. Some specific requirements are attached to this section as supplements.

2.03 SERVICE CONDITIONS

A. Ambient Operating Temperature: 32 degrees F to 104 degrees F.

B. Humidity: 0 percent to 95 percent relative (noncondensing).

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C. Elevation: 6600 feet above sea level.

D. Frequency Stability: Plus or minus 0.1 percent of maximum frequency.

2.04 COMPONENTS

A. Drive Units:

1. Incorporate switching power supply operating from dc bus, to produce PWM output waveform simulating sine wave and providing power loss ride through of 2 milliseconds at full load, full speed.
2. Current-limiting semiconductor fuses for protection of internal power semiconductors.
3. Employ diode bridge rectifier providing constant displacement power factor of 0.95 minimum at all operating speeds and loads.
4. Use transistors for output section, providing a minimum 97 percent drive efficiency at full speed, full load.
5. Employ dc power discharge circuit so that after removal of input power dc link capacitor voltage level will decay below 50 volts dc within 1 minute after de-energizing following NEMA CP 1 and NFPA 79. Design dc link capacitor for a MTBF of **[A: 5] [B:]** years.
6. Operate with open circuited output.
7. Input Voltage: **[C: 480V] [D:]** ac plus or minus **[E: 10] [F:]** percent.
8. Output Voltage: 0 to **[G: 480] [H:]** volts, three-phase, 0 to **[I: 66] [J:]**-Hz, minimum.
9. Maximum peak voltage of PWM AFD output pulse of **[K: 1,000] [L:]** volts, with pulse rise time of not less than 2 microseconds, and maximum rate of rise of **[M: 500] [N:]** volts per microsecond. Maximum frequency of PWM AFD output pulse (carrier) frequency of **[O: 3,000] [P:]**-Hz. Should magnitudes of these characteristics be more stressful to motor insulation than specified values, furnish insulation systems on motors suitable for proposed values.
10. Motor Audible Noise Level: When operating throughout speed range of PWM AFD, no more than **[Q: 3] [R:]** dBA above that designated in NEMA MG 1 for same motor operated at constant speed with a 60-Hz supply voltage.
11. Short-Time Overload Capacity: **[S: 125] [T:]** percent of rated load in rms current for 1 minute following full load, full speed operation.
12. Equipment Short-Circuit Rating: Suitable for connection to system with maximum source three-phase, bolted fault, short-circuit available of **[U: 42,000] [V:]** amps rms symmetrical at **[W: 480] [X:]** volts.
13. Furnish drives with output current-limiting reactors mounted within equipment enclosure.

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14. Diagnostics: Comprehensive for drive adjustment and troubleshooting:
    a. Memory battery backup; 100-hour minimum during power loss.
    b. Status messages will not stop drive from running but will prevent it from starting.
    c. Fault Condition Messages and History: First fault protection function to be activated, ability to store six successive fault occurrences in order. Minimum faults numerically:
        1) Overcurrent (time and instantaneous).
        2) Overvoltage.
        3) Undervoltage (dc and ac).
        4) Overtemperature (drive, motor windings, motor bearing, pump bearing).
        5) Serial communication fault.
        6) Short-circuit/ground fault (motor and drive).
        7) Motor stalled.
        8) Semiconductor fault.
        9) Microprocessor fault.
        10) Single-phase voltage condition.
15. Drive Protection:
    a. Fast-acting semiconductor fuses.
    b. Overcurrent, instantaneous overcurrent trip.
    c. Dc undervoltage protection, 70 percent dropout.
    d. Dc overvoltage protection, 130 percent pickup.
    e. Overtemperature, drive, inverter, converter, and dc link components.
    f. Overtemperature, motor, and pump.
    g. Single-phase protection.
    h. Reset overcurrent protection (manual or automatic reset).
    i. Active current limit/torque limit protection.
    j. Semiconductor fault protection.
    k. Short-circuit/ground fault protection.
    l. Serial communication fault protection.
    m. Microprocessor fault.
    n. Surge protection for transient overvoltage (6,000 volts, 80 joule surge, tested per IEEE C62.41).
    o. Visual display of specific fault conditions.
16. Operational Features:
    a. Use manufacturer’s standard unless otherwise indicated.
    b. Sustained power loss.
    c. Momentary power loss.
    d. Power interruption.
    e. Power loss ride through (0.1 second).
    f. Start on the fly.
    g. Electronic motor overload protection.
    h. Stall protection.

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i. Slip compensation.
j. Automatic restart after power return (ability to enable/disable function).
k. Critical frequency lockout (three selectable points minimum, by 1.5-Hz steps in 10-Hz bands, to prevent resonance of system).
l. Drive maintenance system software for complete programming and diagnostics.
m. Ground fault protection, drive, and motor.
n. Operate with no motor connected to output terminals.

B. Rectifier: Three-phase **[A: 6-pulse] [B: 12-pulse]** full wave diode bridge rectifier to provide constant dc voltage to drive's dc bus.

C. Furnish series choke and capacitors on dc bus to reduce ripple in rectifier output and to reduce harmonic distortion reflected into incoming power feeders.

D. Controller: Microprocessor-controller PWM inverter to convert to dc voltage to variable voltage, adjustable frequency, three-phase ac output. Output voltage shall vary proportionally with frequency to maintain constant ratio of volts to hertz up to 60-Hz; above 60-Hz, voltage shall remain constant with drive operating in constant horsepower output mode.

E. Enclosure:

1. NEMA 250, Type 1, gasketed, freestanding, enclosure for mounting against wall, completely front accessible, and hinged doors. Properly sized to dissipate heat generated by controller within limits of specified operating conditions (including ambient temperature and ambient airflow). Enclosure not to exceed dimensions shown on Drawings.
2. Cable termination compartment door interlocked main circuit breaker, defeatable (lockable in the open position), emergency stop pushbutton, alphanumeric keypad and display, and operator's controls.
[A: Components and controls specified in Section 26 05 04, Basic Electrical Materials and Methods.]
3. Wire drive from **[B: below] [C: and] [D: above]** for power and control wiring.
4. Size forced-ventilation for periodic operation to cool each unit with maximum room ambient temperature of 95 degrees F. Furnish redundant fans such that if one fan fails remaining fans furnish adequate ventilation for drive when operating at maximum capacity. Furnish filters on ventilation intakes.
5. Wiring:
   a. Bundle stranded copper wiring neatly with nylon tie wraps or with continuous plastic spiral binding.
   b. Label each terminal for permanent identification of leads.

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c. Identify each wire at each end with imprinted mylar adhesive-back wire markers.
d. Incorporate in as-installed wiring diagrams for wire and terminal numbers shown.
e. Wiring across door hinge, use 19-strand, NEMA WC 57 Class C stranding looped for proper twist rather than bending at hinge.
f. Wire connections internal to panels by crimp-on terminal types.
g. For multiple enclosure systems, complete interconnection wiring with gasketed enclosure openings for wiring.
h. Multipoint plug receptacles for control wiring crossing equipment shipping splits.

6. Selector switches, indicating lights, potentiometers, instruments, protective devices, and major system components identified by means of mechanically attached, engraved, laminated nameplates.

F. Operator Interface:

1. Controls: Mount drive local control on front door of enclosure and include control switch and membrane type keypad for the following operator functions:
   a. Start (when in local mode).
   b. Stop (when in local mode).
   c. Speed increase (when in local mode).
   d. Speed decrease (when in local mode).
   e. Parameter mode selection (recall programmed parameters).
   f. LOCAL/OFF/REMOTE control selection (in remote, furnish for remote RUN command digital input and speed increase/decrease via remote 4 mA to 20 mA analog signal).
   g. Fault reset, manual for faults, except loss of ac voltage which is automatic upon return.
   h. RUN/preset speed.
   i. Parameter lock, password or key switch lockout of changes to parameters.
   j. Start disable, key switch or programmed code.
2. Control circuit disconnect shall de-energize circuits in units that are not de-energized by main power disconnect device **[A: as required by California Administrative Code]**.
3. 120 volts, single-phase, 60-Hz circuits for control power and operator controls from internal control power transformer. Furnish power for motor space heaters rated 120 volts.
4. Arrange component and circuit such that failure of a single component cannot cause cascading failure(s) of other component(s).

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5. Alphanumeric Display: During normal operation and routine test, the following parameters shall be available:
    a. Motor current (percent of drive rated current).
    b. Output frequency (Hertz).
    c. Output voltage.
    d. Running time.
    e. Local/remote indicator.
    f. Status of digital inputs and outputs.
    g. Analog input and output values.
    h. Output motor current per leg.
    i. All test points.
6. Adjustable Parameters: Set drive operating parameters and indicate in numeric form. Potentiometers may not be used for parameter adjustment. Minimum setup parameters available:
    a. Frequency range, minimum, maximum.
    b. Adjustable acceleration/deceleration rate.
    c. Volts per Hertz (field weakening point).
    d. Active current limit/torque limit, 0 percent to 140 percent of drive rating.
    e. Adjustable voltage boost (IR compensation).
    f. Preset speed (adjustable, preset operating point).
    g. Provision for adjustment of minimum and maximum pump speed to be furnished as function of 4 mA to 20 mA remote speed signal.

G. Signal Interface:

1. Digital Input:
    a. Accept a remote RUN command contact closure input.
    b. High temperature contact closure input from field mounted motor temperature monitoring relay.
2. Digital Output: Furnish three discrete output dry contact closures rated **[A: 5] [B:]** amps at **[C: 120] [D:]** volts **[E: ac.] [F: dc.]**
    a. DRIVE RUNNING.
    b. DRIVE FAULT (with common contact closure for all fault conditions).
    c. DRIVE IN REMOTE MODE.
3. Analog Input: When LOCAL/OFF/REMOTE switch is in REMOTE, control drive speed from remote 4 mA to 20 mA dc signal.
    a. Make provisions for adjustment of minimum and maximum motor speed which shall result from this signal.
    b. Factory set this adjustment to comply with operating speed range designated in driven equipment specifications.
    c. Frequency resolution shall be 0.1 percent of base speed.

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d. **[G: Accept second analog input from speed transmitter located on motor shaft.]**

4. Analog Output: Furnish two 4 mA to 20 mA dc signals for actual frequency, actual load.
5. **[H: Serial Communication Interface: RS232/RS 422, compatible with MODBUS as an RTU.]**

H. Accessories:

1. Equipment Identification Plate: 16-gauge stainless steel with 1/4-inch die-stamped equipment tag number securely mounted in readily visible location.
2. Lifting Lugs: Equipment weighing over 100 pounds.
3. Anchor Bolts: **[A: Galvanized,] [B: Type 316 stainless steel,] [C: sized by equipment manufacturer,] [D: 1/2-inch minimum diameter,]** and as specified in Section 05 50 00, Metal Fabrications.
4. **[E: Motor Protection Relay (MPR): For each drive include a MPR as specified in Section 26 05 04, Basic Electrical Materials and Methods, or furnish functions within drive system. Communications protocol and signal compatibility shall be as required for MPRs.]**

I. **[A: Energy Monitoring System: For each drive include an EMU as specified in [B:] or furnish functions within drive system. Communications protocol and signal compatibility shall be as required for EMUs.]**

2.05 FACTORY FINISHING

A. Enclosure:

1. Primer: One coat of rust-inhibiting coating.
2. Finish:
   a. Interior: One coat white enamel.
   b. Exterior: **[A: One coat manufacturer's standard gray enamel or EIA 359-A-1, No. 61.]**
3. **[B: Manufacturer's standard [C: baked] enamel finish.]**

2.06 SOURCE QUALITY CONTROL

A. Factory Inspections: Inspect control panels for required construction, electrical connection, and intended function.

B. Factory Tests and Adjustments: Test **[A: one] [B:] [C: all]** control panels **[D: actually] [E: identical to that]** furnished.

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C. Record test data for report.

D. Functional Test: Perform **[A: manufacturer's standard,] [B: following tests:] [C:]**.

1. Test diodes, transistors, and GTOs at a thermal level of 125 degrees C.
2. Test TTL and CMOS chips at 70 degrees C.
3. Test printed circuit boards while heat cycled to maximum temperature of 65 degrees C.
4. Test run power sections at maximum 40 degrees C for 12 hours and run with motors for 6 hours.
5. Test assembled drive at maximum 40 degrees C and full load, full speed for 4 hours.
6. Test power capacitors and active components.
7. Operate controller with motor throughout its specified range, and at rated power supply load for 1 hour.
8. Resonance: When harmonic filters are furnished to meet specified harmonic distortion requirements, perform analysis and furnish documentary evidence that filter elements do not resonate with remainder of system parameters at harmonic frequencies present.

E. Motor Test: **[A: See Section 26 20 00, Low-Voltage AC Induction Motors.] [B: .]**

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer's printed instructions.

3.02 FIELD QUALITY CONTROL

A. Functional Test:

1. Conduct on each controller.
2. Inspect controller for electrical supply termination connections, interconnections, proper installation, and quiet operation.
3. Vibration Test:
   a. Complete assembly, consisting of motor, load, and flexible shafting, connected and in normal operation shall not develop amplitudes of vibration exceeding limits recommended by HIS.
   b. Where loads and drives are separated by intermediate flexible shafting, measure vibration both at top motor bearing and at two points on top pump bearing, 90 degrees apart.
4. Record test data for report.

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B. Performance Test:

1. Conduct on each controller.
2. Perform under actual or approved simulated operating conditions.
3. Test for continuous **[A: 12] [B:]**-hour period without malfunction.
4. Demonstrate performance by operating continuous period while varying application load, as input conditions allow, to verify system performance.
5. With plant load connected to normal utility source, measure the following to show parameters within specified limits:
   a. Total and individual current harmonic distortion, up to and including 35th harmonic, at location identified as **[C: PCC1] [D:]** in Simplified Plant One-Line Diagram, under following load conditions:
      1) AFDs running at full load and half load.
      2) Half of specified AFDs running at full load and half load.
   b. Power factor at input side of each drive. Documented verification that power factor is maintained at 95 percent as speed of drive goes down from 100 percent to 33 percent.
   c. THD at location identified as **[E: PCC3] [F:]** under following conditions:
      1) AFDs running at full load and half load.
      2) Half of specified AFDs running at full load and half load.
6. **[G: With plant load connected to standby power source, measure the following to show parameters within specified limits:**
   a. **[H: Total and individual current harmonic distortion, up to and including 35th harmonic, at location identified as [I: PCC2] [J:] in Simplified Plant One-Line Diagram, with [K:] drives running at:**
      1) **Full load.**
      2) **Half load.**
   b. **[L: THD at location identified as [M: PCC3] [N:] in Simplified Plant One-Line Diagram, with [O:] drives running at:**
      1) **Full load.**
      2) **Half load.]**
7. Record test data for report.

C. Test Equipment:

1. Use Dranetz, Model No. 626-PA, harmonic distortion monitor and Series 626 disturbance analyzer or equivalent instrument to document results.

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2. Provide diagnostic plug-in test card complete with instructions, multiposition selector switch, and meters or built-in diagnostic control panel or ROM-based processor for monitoring ac, dc, and digital signals to assist in troubleshooting and startup of drive.

3.03 MANUFACTURERS' SERVICES

A. Manufacturer's Representative: Present at Site or classroom designated by **[A: Owner,] [B: ,]** for minimum person-days listed below, travel time excluded:

1. **[C:]** person-days for **[D: installation assistance] [E: and] [F: inspection.]**
2. **[G:]** person-days for **[H: functional] [I: and] [J: performance]** testing and completion of Manufacturer's Certificate of Proper Installation.
3. **[K:]** person-days for prestartup classroom or Site training.
4. **[L:]** person-days for facility startup.
5. **[M:]** person-days for post-startup training **[N: of Owner's personnel.] [O: Training shall not commence until an accepted detailed lesson plan for each training activity has been reviewed by [P: Owner] [Q: Engineer] [R:].]**

B. See **[A: Section 01 43 33, Manufacturers' Field Services] [B: and] [C: Section 01 91 14, Equipment Testing and Facility Startup.]**

3.04 SUPPLEMENTS

A. The supplements listed below, following "End of Section," are a part of this Specification.

1. Simplified Plant One-Line Diagram.

END OF SECTION

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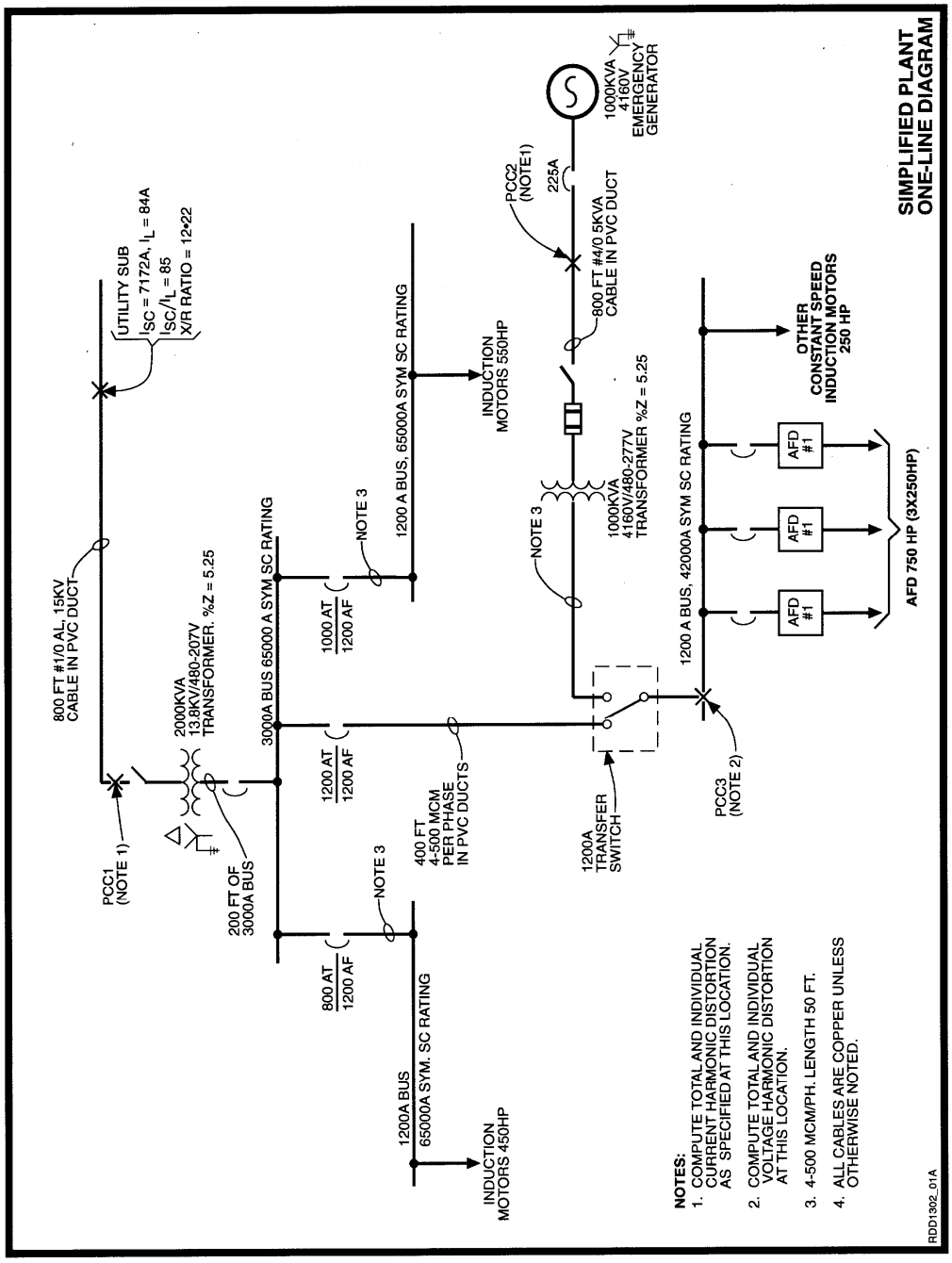

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SECTION 26 29 25
DC-SCR DRIVE SYSTEMS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Bearing Manufacturers' Association (ABMA): 10, Metal Balls.
2. Institute of Electrical and Electronics Engineers (IEEE): Standard 519, Guide for Harmonic Control and Reactive Compensation of Static Power Converters.
3. National Electrical Manufacturers Association (NEMA):
   a. MG 1, Motors and Generators.
   b. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).

1.02 SUBMITTALS

A. Action Submittals:

1. Complete catalog information, descriptive literature, specifications, and identification of materials of construction.
2. Detailed mechanical, and electrical drawings showing the equipment dimensions, size, and locations of connections.
3. Layout of controller face showing all pushbuttons, switches, instruments, indicating lights, and similar devices.
4. Complete system operating description.
5. Complete system schematic (elementary) wiring diagrams.
6. Complete system interconnection diagrams between controller, drive motor, and related components or controls external to the system, including wire numbers and terminal board point identification.
7. Seismic anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.

B. Informational Submittals:

1. Seismic anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Special shipping, storage and protection, and handling instructions.
3. Manufacturer's printed installation instructions.
4. Suggested spare parts list to maintain the equipment in service for a period of **[A: 1 year] [B: and] [C: 5 years]**. Include a list of special

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tools required for checking, testing, parts replacement, and maintenance with current price information.

5. List special tools, materials, and supplies furnished with equipment for use prior to and during startup and for future maintenance.
6. Operation and Maintenance Data: As specified in Section 01 78 23, Operation and Maintenance Data.
7. Manufacturer's Certificate of Proper Installation, in accordance with Section **[D: 01 43 33, Manufacturers' Field Services] [E:]**.

1.03 QUALITY ASSURANCE

A. Minimum 5 years' experience in furnishing similar size and type DC-SCR, controlled speed, drive systems.

1.04 ENVIRONMENTAL REQUIREMENTS

A. Ambient Operating: 32 to 104 degrees F.

B. Storage Temperature: Minus 40 to 158 degrees F.

C. Humidity: 0 to 95 percent relative (noncondensing).

D. Altitude: 0 to 3,300 feet.

PART 2 PRODUCTS

2.01 GENERAL

A. Where specified by the pump vendor, furnish drive systems including solid state dc drive, dc motor, and accessories capable of converting the specified input power into adjustable speed power to drive system.

B. Controller and motor shall be compatible with each other and horsepower rated for service application.

2.02 DRIVE SYSTEM REQUIREMENTS

A. General: Controller shall convert 120 volts single-phase ac power to dc power for the drive motor.

1. Drive Horsepower Rating: As required to drive connected motor under full load conditions.

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B. Features:

1. Stroking Speed: Regulated by potentiometer, manual adjustment in LOCAL and isolated 4 to 20 mA dc signal in REMOTE.
2. SCR Controller and dc Motor Protection: Circuit breaker or fused switch and control unit disconnect from input ac electric line supply.

C. Special Features: Speed regulation 0.5 percent with 4-20mA feedback.

D. Operator Controls:

1. ON/OFF/AUTO switch with provisions to run from a remote maintained contact in AUTO mode.
2. Speed control potentiometer.
3. Speed indicator.
4. Motor RUNNING indication light, red.
5. Drive FAIL and motor HIGH TEMPERATURE indication lights, amber.
6. RESET pushbutton to turn off motor HIGH TEMPERATURE and FAIL indication lights and allow drive to restart.
7. LOCAL/REMOTE selector switch.

E. External Interfaces:

1. Dry contact output rated 5A at 120V ac, minimum, to close when drive FAIL or motor HIGH TEMPERATURE condition exists.
2. Dry contact output rated 5A at 120V ac, minimum, to close when drive is running.
3. Accept contact input to run drive in REMOTE mode when remote contact is closed.
4. Accept 4 to 20 mA dc remote speed control signal using an isolated current-to-voltage converter.

F. Controller Enclosure: NEMA 250, Type 4X.

PART 3 EXECUTION

3.01 GENERAL

A. See driven equipment specifications.

END OF SECTION

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SECTION 26 32 13.13
DIESEL ENGINE GENERATOR SET

PART 1 GENERAL

1.01 SUBMITTALS

A. Action Submittals:

1. Engine and generator weights.
2. Equipment anchorage data.
3. Catalog information and technical description of major components.
4. Complete list of accessories provided.
5. Performance curves showing engine efficiency (fuel consumed per kWh output), gross fuel consumption rates, and kW output at design rated output, one-half load, and one-quarter load. Account for design altitude, temperature corrections, and engine parasitic loads.
6. Generator transient and subtransient reactances per unit.
7. Generator output waveform and telephone interference factor (TIF).
8. Generator circuit breaker data.
9. Electrical schematic and wiring diagrams for the following:
    a. Generator control panel.
    b. Main generator.
    c. Voltage regulator.
    d. Battery charging system.
    e. Governing system.
10. Control panel instrument identification inscriptions.
11. Engine generator set motor starting capability and percent voltage dip curve.
12. Block heater size and voltage.
13. Documentation to support air permit process as required by the local rules and regulations.
14. Seismic anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.

B. Informational Submittals:

1. Seismic anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. All test data and documentation on the specific serial-numbered equipment required to finalize the air permit process as required by the local rules and regulations.
3. Operation and Maintenance Data: As specified in Section 01 78 23, Operation and Maintenance Data.
4. Description of parts.

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5. Certification, copies of analyses, or test reports demonstrating appropriate vibration analysis and design in all modes.
6. Factory Test Report.
7. Special warranty.

C. Record submittal, revised pre-shipping submittal plus as-built changes:

1. Incorporate as-built changes made by the electrical installer.
2. Manufacturer's Certificate of Proper Installation.

1.02 QUALITY ASSURANCE

A. Authority Having Jurisdiction (AHJ):

1. Provide the Work in accordance with NFPA 70, National Electrical Code (NEC). Where required by the AHJ, material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ in order to provide a basis for approval under NEC.
2. Materials and equipment manufactured within the scope of standards published by Underwriters Laboratories, Inc. shall conform to those standards and shall have an applied UL listing mark.

B. Manufacturer Special Requirements:

1. Generator set shall be listed to UL 2200 or submitted to an independent third party certification process to verify compliance as installed.
2. Manufacturer of generator set shall be certified to ISO 9001 and shall have third party certification verifying quality assurance in design/development, production, installation, and service, in accordance with ISO 9001.

1.03 AIR QUALITY PERMIT

A. **[A: Obtain prior to releasing generator for production.] [B: Provided by [C: Engineer.] [D: Owner.]]**

1.04 SPECIAL GUARANTEE

A. Provide manufacturer's warranty with no deductibles and including travel time, service hours, and repair parts with D/B Contractor named as beneficiary. This Warranty shall be transferable at such time as deemed necessary by the D/B Contractor. Warranty shall provide for correction, or at the option of D/B Contractor, removal and replacement of the Work specified in this Specification section found defective during the indicated period after the date of Substantial Completion Acceptance by D/B Contractor. Duties and

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obligations for correction or removal and replacement of defective Work as specified in the General Conditions.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Materials and equipment specified in this section shall be products of:

1. Caterpillar.
2. Cummins.
3. Kohler Power Series; Model.
4. MTU OnSite Energy Systems.

2.02 SERVICE CONDITIONS

A. Ambient Temperature at Air Intake: 104 degrees F maximum.

B. Elevation: 6600 feet above sea level.

2.03 GENERAL

A. Ratings:

1. Operate at 1,800 rpm.
2. Rated at **[D: kW] [E: kVA]** at 0.8 PF, based on specified service conditions.
3. Voltage: 480Y/277 volts, three-phase, three-wire, 60-Hz.
4. Rated based on standby service.

B. Emissions:

1. Engines shall meet emission requirements specified in 40 CFR Chapter I Part 89 for off-highway Internal Combustion (IC) engines.

C. Vibration Design:

1. Use vibration analytical techniques to determine shaft critical speeds, and to develop bearing design and shaft balancing to mitigate vibration.
2. Apply torsional analysis and design to mitigate torsional vibration.
3. Engine and generator, individually, shall not exhibit vibration in any plane exceeding 10 mils at continuous rating point, when measured at attachment points to common steel subbase.

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2.04 ENGINE

A. General:

1. Manufacturer’s standard design, unless otherwise specified.
2. Engine parts designed with adequate strength for specified duty.

B. Type: Diesel Cycle, four-stroke type with unit mounted radiator and fan cooling.

C. Starting System:

1. Type: Automatic, using 12-volt or 24-volt battery-driven starter acting in response to control panel.
2. Starter shall be capable of three complete cranking cycles without overheating.
3. Batteries:
   a. Sized as recommended by engine manufacturer.
   b. Lead-acid type.
   c. Capable of providing 15 seconds minimum of cranking current at 0 degree C and three complete 15-second cranking cycles at 40 degrees C.
   d. Housed in acid-resistant frame isolated from engine generator main frame.
   e. Located such that maintenance and inspection of engine is not hindered.
   f. Complete with battery cables and connectors.
   g. Electric battery warmer plate.
4. Battery Charger:
   a. UL 1236 listed and labeled.
   b. 10-amp automatic float, taper and equalize charge type, with plus or minus 1 percent voltage regulation over a plus or minus 10 percent input voltage variation.
   c. Temperature compensated to operate over an ambient range of minus 30 degrees C to 50 degrees C.
   d. Locate charger in automatic transfer switch, generator control panel, or wall mounted in generator enclosure. Generator manufacturer shall coordinate location.
   e. Include:
      1) Ammeter and voltmeter.
      2) Fused ac input and dc output.
      3) Power ON pilot light.
      4) AC failure relay and light.
      5) Low and high dc voltage alarm relay and light.
   f. Alarm relay dry contacts rated 4 amps at 120V ac.

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g. Wire battery charger status and alarm contacts back to generator control panel, terminate and identify contacts.

D. Fuel System:

1. Engine driven, mechanical, positive displacement fuel pump.
2. Fuel filter with replaceable spin-on canister element.
3. Fuel Connections to Engine: Flexible hose, suitable for application.

E. Governing System:

1. Electro-mechanical or electro-hydraulic type.
2. Regulates speed as required to hold generating frequency within tolerable limits and within 5 percent of nominal design speed.
3. Accessories:
   a. Manual speed control device.
   b. Positive overspeed trip switch.

F. Jacket Water Cooling System:

1. Radiator:
   a. Consisting of jacket water pump, fan assembly, fan guard, and duct flange outlet.
   b. Cooling System: Rated for full load operation as specified in Article Service Conditions.
   c. Fan: Suitable for use in a system with 0.5 in H_2O restriction.
   d. Sized based on a core temperature that is 20 degrees F higher than rated operation temperature.
2. Engine Thermostat: As recommended by manufacturer to regulate engine water temperature.
3. Jacket Water Heater:
   a. Suitable for operation on 480–volt, single-phase, 60-Hz current.
   b. Maintain engine water temperature at 120 degrees F with an ambient temperature of 50 degrees F.
   c. Thermostatically controlled.
4. Engine Cooling Liquid: Fill cooling system with a 50/50-ethylene glycol/water mixture prior to shipping.

G. Lubrication System:

1. Type: Full-pressure.
2. Accessories:
   a. Pressure switch to initiate shutdown on low oil pressure.
   b. Oil filter with replaceable element.
   c. Bayonet type oil level stick.
   d. Valved oil drain extension.

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3. Oil Cooling System: Water-cooled heat exchanger utilizing jacket water.

H. Exhaust System:

1. Muffler: Rated for **[A: residential silencing] [B: as recommended by generator manufacturer to meet noise requirements specified under Article Sound Attenuation]**.
2. **[C: Wrap exposed length of exhaust pipe and silencer with thermal insulating wrap.]**
3. Exhaust Pipe: ASTM A335, Grade P11, standard wall, with fittings selected to match piping materials.
4. Pipe Connections: Welded.
5. Engine Connection:
   a. Flanged, flexible, corrugated, Type 321 stainless steel expansion fitting, specifically suited for diesel exhaust service.
   b. Length as required for flexibility and expansion in piping arrangement shown on Drawings.

I. Air Intake System: Equip with dry type air cleaner with filter service (restriction) indicator.

2.05 GENERATOR

A. General:

1. Meet requirements of NEMA MG 1.
2. Synchronous type with 2/3 pitch, revolving field, drip-proof construction, air cooled by a direct drive centrifugal blower fan.
3. Stator Windings:
   a. Skewed for smooth voltage waveform.
   b. Reconnectable, 12 lead.
4. Overspeed Capability: 125 percent.
5. Waveform Deviation from Sine Wave: 5 percent maximum.
6. Telephone Interference Factor: 50 maximum.
7. Total Harmonic Current and Voltage Distortion: 5 percent maximum, measured at generator main circuit breaker.

B. Insulation System: Class H.

C. Excitation System:

1. Field brushless type or permanent magnet generator (PMG) exciter.
2. PMG and Controls: Capable of providing regulated current, at a rate of 300 percent of nameplate current, to a single-phase or three-phase fault for 10 seconds.

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D. Voltage Regulation:

1. Solid state, three-phase sensing type.
2. Adjustable output voltage level to plus or minus 5 percent.
3. Provisions for proper voltage regulation for existing or future adjustable frequency drives as part of generator load.
4. Conformal coating environmental protection.

E. Voltage and Frequency Regulation Performance:

1. Steady State Voltage Regulation: Less than plus or minus 1 percent from no load to continuous rating point.
2. NEMA MG 1 Defined Transient Voltage Dip:
   a. Less than **[A: 20] [B: 15]** percent at rapid application of rated load.
   b. Recovery to rated voltage and frequency within 2 seconds following initial load application.
3. Steady State Frequency Regulation: Plus or minus 1.5-Hz overload range.

F. Short Circuit Capabilities: Sustain 300 percent of rated current for 10 seconds for external three-phase bolted fault without exceeding rated temperatures.

G. Main Circuit Breaker:

1. Type: Molded case. Insulated case.
2. Current Rating: As recommended by generator manufacturer.
3. Interrupt Rating: 35,000 amps RMS symmetrical at **7--** volts.
4. Trips:
   a. **[H: Thermal-magnetic with inverse time characteristics and adjustable magnetic pickup.]**
   b. Solid state, RMS sensing.
   c. Adjustable Functions:
      1) Long-time current pickup.
      2) Long-time delay.
      3) Normal range instantaneous.
      4) Short-time pickup. short-time delay.
      5) **[P: Ground fault pickup.]**
      6) Ground fault delay.
      7) Zone selective interlock (ZSI), compatible with ZSI system in switchgear/switchboard and automatic transfer switch.
5. Surge Protective Devices: Three-phase capacitors and arresters mounted in terminal compartment.

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2.06 BASEPLATE

A. Mount engine generator set on a rigid common steel base frame.

B. Base frame shall be stiffened to minimize deflections.

2.07 INTEGRAL SUBBASE FUEL TANK

A. General:

1. Full load operation of generator set for 48 hours.
2. UL 142 listed and labeled.
3. Installation shall be in compliance to NFPA 37.
4. Double-walled, steel construction and shall include the following features:
    a. Emergency tank and basin vents.
    b. Mechanical level gauge.
    c. Fuel supply and return lines, connected to generator set with flexible fuel lines as recommended by engine manufacturer and in compliance to UL 2200 and NFPA 37 requirements.
    d. Leak detection provisions, wired to generator set control for local and remote alarm indication.
    e. High and low level float switches to indicate fuel level. Wire switches to generator control for local and remote indication of fuel level.
    f. Basin drain.
    g. Integral lifting provisions.

2.08 VIBRATION ISOLATORS

A. Performance: To meet code requirements specified in Section 01 61 00, Common Product Requirements.

B. Provide vibration isolators, spring/pad type.

C. Include seismic restraints if required by Site location.

2.09 AUTOMATIC LOAD TRANSFER CONTROL

A. Automatic run controls shall be suitable for remote interface and control by automatic transfer switch. Engine generator set shall start and run upon closure of a remote dry contact provided in Section 26 36 23, Automatic Transfer Switch.

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2.10 CONTROL SYSTEM

A. Control Panel:

1. Rating: **[A: NEMA 250, Type 12.] [B: .]**
2. Material: Steel.
3. Instrument Identification: Face label or engraved, black, laminated plastic nameplate with white 1/4-inch-high letters, attached with Type 422 stainless steel screws.
4. UL 508 listed.
5. Tested to meet or exceed IEEE 587 requirements for voltage surge resistance.
6. Controls shall be solid-state, microprocessor based. Control panel shall be designed and built by generator manufacturer and shall provide operating, monitoring, and control functions for generator set.
7. Control Panel mounting height shall not exceed 6 feet 6 inches above where personnel will access panel, Manufacturer shall modify mounting height if a sub-base fuel tank is used.

B. Instrumentation:

1. Type: Suitable for engine-mounted vibration environment.
2. Mounting: Nonshock mounted.
3. Alarm and Signal Contacts: Rated 5 amps at 120V ac, dry.
4. Fault Indication Lamps: Manufacturer’s standard.
5. Meters: Digital.

C. Operator Controls and Indicators:

1. HANDCRANK/STOP/AUTO/ENGINE TEST selector switch.
2. Generator voltage adjustment.
3. Voltmeter PHASE SELECTOR switch.
4. Ammeter PHASE SELECTOR switch.
5. Voltmeter.
6. Ammeter.
7. Kilowatts (kW).
8. Percent kW.
9. Power Factor.
10. FREQUENCY.
11. Engine OIL PRESSURE.
12. Engine jacket WATER TEMPERATURE.
13. Engine SPEED (RPM).
14. Engine OIL TEMPERATURE.
15. RUNNING TIME.
16. DC battery voltage.
17. Emergency Stop button.

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D. Alarm Indicators with Manual Pushbutton RESET:

1. Low oil pressure.
2. High jacket water temperature.
3. Engine overspeed.
4. Engine overcrank.
5. Low/high dc voltage.

E. External Interfaces:

1. Furnish a single, common DPDT relay output upon occurrence of alarm condition.
2. Output: Dry contact rated 5 amps at 120V ac.
3. Accept remote dry start contact closure from automatic transfer switch, rated 10 amps at 32V dc.

F. Functional Requirements:

1. LCD text display of alarm/event descriptions.
2. Recranking Lockout: When engine fires, starting control shall automatically disconnect cranking control to prevent recranking for a preset period of time after engine stop.
3. Overcranking Lockout: Initiate after four cranking cycles of 10 seconds on and 10 seconds off or provide continuous cranking cycle with crank time limiter.
4. Cooldown timer, adjustable from 5 minutes to 60 minutes.
5. Alarms:
   a. Low coolant level.
   b. Low fuel level.
   c. Low battery voltage.
   d. High battery voltage.
   e. Battery charger failure.
6. Engine shutdown upon any of the following conditions:
   a. Engine overspeed.
   b. Emergency stop button depressed.
   c. High jacket water temperature Low oil pressure.
7. Mount battery charger in automatic transfer switch specified in Section 26 36 23, Automatic Transfer Switches.

2.11 OUTDOOR WEATHER-PROTECTIVE ENCLOSURE

A. General:

1. Provide generator set with outdoor enclosure, with entire package listed under UL 2200.

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2. Package shall comply with requirements of NEC for wiring materials and component spacing.
3. Design total assembly of generator set, enclosure, and subbase fuel tank (when used) to be lifted into place using spreader bars.
4. Housing:
    a. Provide ample airflow for generator set operation at rated load in ambient temperature of 100 degrees F.
    b. Doors:
        1) Hinged access doors as required to maintain easy access for operating and service functions.
        2) Lockable and include retainers to hold door open during service.
5. Roof: Cambered to prevent rainwater accumulation.
6. Openings: Screened to limit access of rodents into enclosure.
7. Electrical power and control interconnections shall be made within perimeter of enclosure.
8. Finishes:
    a. Prime sheet metal for corrosion protection and finish painted with manufacturer's standard color using a two-step electrocoating paint process, or equal meeting performance requirements specified below.
    b. Prime and paint surfaces of metal parts. Painting process shall result in coating that meets the following requirements:
        1) Primer: 0.5 mil to 2.0 mils thick.
        2) Top Coat: 0.8 mil to 1.2 mils thick.
        3) Gloss:
            a) Per ASTM D523, 80 percent plus or minus 5 percent.
            b) Gloss retention after 1 year shall exceed 50 percent.
        4) Crosshatch Adhesion: Per ASTM D3359, 4B-5B.
        5) Impact Resistance: Per ASTM D2794, 120-inch to 160-inch pounds.
        6) Salt Spray: Per ASTM B117, plus 1,000 hours.
        7) Humidity: Per ASTM D2247, plus 1,000 hours.
        8) Water Soak: Per ASTM D2247, plus 1,000 hours.
    c. Painting of hoses, clamps, wiring harnesses, and other nonmetallic service parts shall not be acceptable.
    d. Fasteners used shall be corrosion-resistant and designed to minimize marring of painted surface when removed for normal installation or service work.
9. Enclosure shall be constructed of minimum 12-gauge steel for framework and 14-gauge steel for panels.
10. Hardware and hinges shall be austenitic stainless steel.

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11. Exhaust Silencer:
    a. Install factory-mounted exhaust silencer inside enclosure.
    b. Exhaust shall exit enclosure through a rain collar and terminate with a rain cap.
    c. Exhaust connections to generator set shall be through seamless flexible connections.
12. Maintenance Provisions:
    a. Flexible coolant and lubricating oil drain lines that extend to exterior of enclosure, with internal drain valves.
    b. External radiator-fill provision.
    c. External fuel fill provision (if equipped with a subbased fuel tank).
13. Provide motorized louvers to minimize air flow through enclosure when generator set is not operating. Louvers shall include provisions to prevent accumulation of ice or snow that might prevent operation.
14. Inlet ducts shall include rain hoods.
15. Provide external emergency stop switch that is protected from accidental actuation.
16. Provide factory mounted and wired electrical distribution panel to serve generator set and enclosure. Provisions required include:
    a. 100-amp distribution panelboard connected to a 120/240V ac utility service.
    b. Two duplex GFI receptacles, one inside enclosure, and one weatherproof receptacle on outside of enclosure.
    c. Two three-way switches controlling three ac lamps mounted in vapor tight and gasketed fixtures.
    d. Factory-wired normal ac service from panelboard to engine coolant and alternator heaters, and battery charger.
17. Sound Attenuation:
    a. Provide with sound-attenuated housing which allows generator set to operate at full rated load in an ambient temperature of up to 100 degrees F.
    b. Enclosure shall reduce sound level of generator set while operating at full rated load to a maximum of 80 dBA at any location 7 meters from generator set in a free field environment when tested in accordance with SAE J1074.
    c. Insulate enclosure with nonhydroscopic materials.

2.12 FACTORY FINISHING

A. Engine Generator Set and Instrument Panel: Manufacturer’s standard.

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2.13 FACTORY TESTS

A. General: Conform to NFPA 110.

B. Steady Load Test: Test engine generator set at steady load run of 60 minutes minimum duration at 100 percent full-rated load.

C. Transient Load Test: Conduct transient load test to demonstrate ability to meet load pickup and load release requirements specified.

D. Harmonic Test: Conduct at full load conditions.

E. Record and Report:

1. Strip chart recording and full harmonic analysis measuring up to 50th harmonic for both voltage and current and three phases simultaneously.
2. Transient response.
3. Load/speed stability.
4. Engine fuel consumption.
5. Power output.
6. Harmonic analysis.

PART 3 EXECUTION

3.01 INSTALLATION

A. Level and securely mount engine generator set in accordance with manufacturer's recommendations.

B. Install in accordance with NECA 404.

C. Where applicable, mount engine generator set on vibration isolators in accordance with isolator manufacturer's recommendations.

3.02 FIELD FINISHING

A. Touch up damaged coating with paint system compatible to existing.

3.03 FIELD TESTS

A. General: Conform to NFPA 110.

B. Performance Test:

1. Perform upon completion of installation.
2. Operate 2 hours minimum.
3. Manufacturer's representative shall make necessary adjustments.

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4. Demonstrate ability of engine generator set to carry specified loads.
5. Demonstrate engine generator set safety shutdowns.

C. Test Report: Record and report the following:

1. Electric load on generator.
2. Fuel consumption.
3. Exhaust temperature.
4. Ambient air temperature.
5. Safety shutdown performance results.
6. **[A: Noise levels at [B: 7 meters] [C: Property line].]**

D. Post-test Requirements:

1. Make final adjustments.
2. Replace fuel and oil filters.
3. Check belt drive tensions.
4. Demonstrate proper operation of equipment, including automatic operation with control from automatic transfer switch, to Engineer and Owner.

3.04 MANUFACTURER'S SERVICES

A. Manufacturer's Representative: Present at Site or classroom designated by CH2M for minimum person-days listed below, travel time excluded:

1. 3 person-days for installation assistance and inspection.
2. 2 person-days for functional testing and completion of Manufacturer's Certificate of Proper Installation.
3. 1 person-day for post-startup training operating personnel. Training shall not commence until an accepted detailed lesson plan for each training activity has been reviewed and approved by CH2M.

B. See Section 01 43 33, Manufacturers' Field Services and Section 01 91 14, Equipment Testing and Facility Startup.

END OF SECTION

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SECTION 26 33 53
STATIC UNINTERRUPTIBLE POWER SUPPLY

PART 1 GENERAL

1.01 SUMMARY

A. Section includes the requirements necessary to furnish and install static uninterruptible power supplies (UPS) including but not limited to:

1. UPS Modules.
2. System Control Switchgear with static bypass.
3. Battery System.
4. Battery Protective and Disconnect Devices.
5. Maintenance Bypass Switch.

1.02 SYSTEM DESCRIPTION

A. System Configuration: Redundant Uninterruptible Power System.

B. Components: System includes battery to provide continuous source of electrical power, rectifier/charger to maintain battery charge and to provide input to inverter when utility power is available, inverter to provide power to load during normal operation, static switch to transfer load automatically and without disturbance between inverter and utility power, manual switch to bypass static switch for maintenance, input and output isolation transformers and filters to provide appropriate isolation and disturbance attenuation, and necessary monitors, sensors, and control circuits.

C. Design Standards:

1. UL 1778, Underwriter Laboratories Standard for Safety Uninterruptible Power Systems.
2. CSA 22.2, Canadian Standards Association, cUL Equipment.
3. IEEE 587, ANSI C62.41, Institute of Electrical and Electronic Engineers Guide for Surge Voltages in Low Voltage AC Power Circuits.
4. NFPA 70, National Fire Protection Association, National Electrical Code.
5. OSHA, Occupational Safety and Health Administration.
6. NEMA PE-1, National Electrical Manufacturer’s Association, Uninterruptible Power Systems – Specification and Performance Verification.

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D. Modes of Operation:

1. Normal: The inverters continuously powers the critical load. The rectifier/chargers derives power from the utility AC source and supplies DC power to the inverters, while simultaneously float charging the batteries.
2. Emergency: Upon utility AC power failure, without any switching, the inverters obtains power from the batteries and provides uninterrupted power to the critical AC load. Designed to have no interruption in power to the critical load upon failure or restoration of the utility ac source.
3. Recharge: Upon restoration of the utility AC source, the rectifier/ chargers automatically powers the inverters and simultaneously recharges the batteries with no interruption to the critical AC load.
4. Bypass: If the UPS must be taken out of service for maintenance or repair, the bypass switch transfers the load to the bypass source with no output disturbance transferred to the AC critical load.

1.03 WARRANTY

A. UPS: Provide warranty against defects in workmanship and materials for 12 months after initial startup or 18 months after ship date, whichever comes first.

B. Battery: Pass the battery manufacturer’s standard warranty to the end user.

C. Warranty – End User: Pass warranties associated with buy-out items to the end user.

1.04 QUALITY ASSURANCE

A. Manufacturer: Company specializing in UPS equipment with 10 years documented experience.

B. Factory Tests: Test complete system at factory and calibrate prior to shipment, include full-load test at rated power factor.

1.05 SUBMITTALS

A. Action Submittals:

1. Catalog cut sheets and other descriptive literature with model numbers, capacities and ratings.
2. Layout drawings with dimensions for major components.
   a. Mounting details.
   b. System single-line diagram.
   c. Wiring diagrams.

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3. Weights of assembled enclosures.
4. Heat rejection and ventilation requirements at full load.

B. Informational Submittals:

1. Operations and Maintenance (O&M) manuals.
   a. Onsite testing procedures.
   b. Troubleshooting guides.
   c. Software files and databases.
   d. Parts lists.
   e. Manufacturer's service representative contact information.

1.06 ENVIRONMENTAL REQUIREMENTS

A. Operating Ambient Temperature:

1. UPS: 32 to 104 degrees F.
2. Battery: 77 degrees F, plus or minus 5 degrees F.

B. Storage/Transport Ambient Temperature: Minus 4 to 158 degrees F.

C. Relative Humidity: 0 to 95 percent, noncondensing.

D. Audible Noise: Limit noise generated by UPS under conditions of normal operation below sound pressure level of 75 db measured at 5 feet from the UPS cabinet.

1.07 DELIVERY, STORAGE AND HANDLING

A. Protect UPS and accessories from moisture by using appropriate heaters or desiccants as instructed by manufacturer.

B. Store UPS and accessories in a clean, dry space. Maintain wrapping or provide additional heavy canvas or plastic cover to protect from dirt, water, construction debris, and traffic.

C. Handle UPS and accessories in accordance with NEMA and manufacturer’s written instructions. Lift only with lugs provided for the purpose. Handle carefully to avoid damage to internal components, enclosure, and finish.

1.08 MAINTENANCE SERVICE

A. Manufacturer’s Field Service:

1. Service Personnel:
   a. Directly employ a nationwide service organization, consisting of factory-trained field service personnel dedicated to the start-up and maintenance of UPS and power equipment.

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b. A dispatch center to coordinate field service personnel schedules. One toll-free number shall reach a qualified support person 24 hours per day, 365 days per year. If emergency service is required, onsite service shall be four hours or less within 150 miles of a service center.

B. Maintenance Contracts: A complete offering of preventative and full-service maintenance contracts for both the UPS system and battery system shall be available.

PART 2 PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Eaton.

B. Emerson.

C. Schneider Electric.

2.02 SYSTEM RATINGS AND OPERATING CHARACTERISTICS

A. System Continuous Rating: As shown on the Drawings, with one UPS module out of service. Maintain output voltage within specified limits at loads from full load to no load.

B. Battery Capacity:

1. Discharge Time to End Voltage: 30 minutes at full load, 77 degrees C.

C. Voltage Rating:

1. Input:
   a. Single Phase: 120 volts.
2. Output:
   a. Single Phase: 120 volts.
   b. Provide required transformers to allow static switch bypass and/or overall system manual bypass and alternate feed to function with selected input and output voltages.

D. Equipment Short-Circuit Rating: 22,000 A rms.

2.03 UPS MODULE PERFORMANCE REQUIREMENTS

A. Input:

1. Voltage Range: Plus or minus 10 percent.
2. Frequency Range: 60, plus or minus 3 Hz.

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3. Power Factor: Minimum 0.85 lagging at full load with nominal input voltage.
4. Surge Protection: Sustains input surges without damage per criteria listed in ANSI C62.41-1980.

B. Output:

1. Load Rating: 100 percent continuous load rating at 0 to 104 degrees F for any combination of linear and non-linear load.
2. Voltage Regulation: Plus or minus 1 percent for steady state load.
3. Voltage Adjustment: Plus or minus 5 percent.
4. Free Running Frequency: 60 Hz, plus or minus 1.0 percent.
5. Frequency Regulation: 0.1 percent.
6. Voltage Transients:
   a. 100 Percent Load Step: Plus or minus 3 percent.
   b. Loss or Return of AC Input Power: Plus or minus 3 percent with 5-millisecond recovery time.
   c. Transfer to/from Bypass: Plus or minus 5 percent.
7. Voltage Transient Recovery Time: Within 1 percent of output voltage rating within one electrical cycle (16 milliseconds).
8. Harmonic Distortion: Maximum 5 percent rms voltage THD and maximum 3 percent for any single harmonic, at rated frequency and voltage, from 10 percent load to full load and over battery voltage range, measured into a linear load.
9. Current Limit: 125 percent of rated output current.
10. Fault Clearing: Sub-cycle current of at least 300 percent but not more than 500 percent of normal full load current (when bypass is not available).
11. Power Factor: 0.70 lagging.

2.04 DESIGN AND CONSTRUCTION

A. UPS Materials:

1. Provide all new materials for UPS modules with solid-state electronic devices, sealed semi-conductors, and control logic and fuses that are physically isolated from power train components.
2. The maximum working voltage, current, and di/dt of all solid-state power components and electronic devices shall not exceed 75 percent of the ratings established by their manufacturer.
3. Electrolytic capacitors shall be computer grade and operated at no more than 95 percent of their voltage rating at the maximum rectifier charging voltage.

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B. Mechanical Design Features:

1. Enclosure:
   a. Construction: NEMA Type 1 enclosure designed for floor mounting.

C. Protection:

1. If short-circuit fault occurs downstream of UPS, load is to be transferred automatically and without interruption, by static switch to input line. After fault is cleared by capacity of input line and load current returned to normal, then static switch is to automatically retransfer without interruption of load, back to inverter.
2. Temperature Compensated Battery Charging: Battery charging rate is compensated in proportion to change in battery temperature. Based on battery temperature input from the battery monitoring system, battery charge voltage is reduced by a preset value per cell for every degree above 25 degrees C and increased by the preset value per cell for every degree below 25 degrees C. The module LCD will indicate when the temperature compensation is active.
3. Over-voltage Protection: Provide DC over-voltage protection within each module so that if the DC voltage rises to the pre-set limit, that UPS module shall shut down automatically. In the Multi-Module UPS System should the connected critical load exceed the capacity of the available on-line modules, the system control cabinet will initiate an uninterrupted load transfer to bypass.

2.05 MAINTENANCE BYPASS/ISOLATION

A. Description: A make-before-break maintenance bypass switch to route the flow of power to the load around the rectifier/charger, inverter, and static bypass transfer switch.

1. Switch shall be electrically and mechanically interlocked to prevent interrupting power to the load when switching to bypass mode.
2. Switch shall electrically isolate other UPS components to permit safe servicing.

2.06 CONTROLS AND INDICATORS

A. UPS Control Panel: Group displays, indications, and basic system controls on a common control panel on front of UPS enclosure.

1. Provide logic microprocessors, sensors, transducers, terminals, relays, and wiring required to support manufacturer’s standard control and alarm functions.

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2. Operator Guidance: Provide menu-driven operator instructions detailing the operation of the UPS system.
    a. The instruction menu shall be located at the control panel.
    b. The UPS logic microprocessor shall monitor each step, thus prompting itself to the next step of the instructions.

B. Dry Contacts: Provide form-C isolated dry contacts for external use to monitor:

1. Summary alarm.

2.07 STORAGE BATTERY

A. Furnish a storage battery for UPS with sufficient capacity to maintain UPS output at required load for minimum specified time. Battery to provide 100 percent of specified capacity at initial startup. Provide heavy-duty industrial type battery designed for stationary power service.

B. Provide NiCad batteries. Provide impact- resistant plastic container of a design proven by field experience.

C. Battery to have sufficient capacity to supply load for 30 minutes.

D. Supply battery with the following:

1. Cabinets, protected with electrolyte-resistant paint.
2. Intercell and interior connectors for racks, end to end and/or back to back. Maximum connection voltage drop of 30 mV between adjacent units.
3. Special tools and fittings required to assemble battery.
4. Cell numerals.
5. DC disconnect.
6. Barriers battery terminals to prevent accidental contact with battery terminals.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer’s instructions.

B. Secure enclosures and racks to floor.

C. Include services of technician to supervise adjustments, final connection, and system energization.

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3.02 FIELD QUALITY CONTROL

A. Onsite Tests: Provide onsite factory-trained technician to supervise installation and testing.

B. Field UPS Start-up Inspection and Testing:

1. Visual Inspection:
   a. Inspect equipment for signs of damage.
   b. Verify installation per drawings.
   c. Inspect cabinets for foreign objects.
   d. Verify neutral and ground conductors are properly sized and configured per vendor requirements as noted in vendor drawings supplied with installation manuals or submittal package.
   e. Inspect all battery cell cases.
   f. Inspect each cell for proper polarity.
   g. Verify all printed circuit boards are configured properly.
2. Mechanical Inspection:
   a. Check all control wiring connections for tightness.
   b. Check all power wiring connections for tightness.
   c. Check all terminal screws, nuts, and/or spade lugs for tightness.
3. Electrical Inspection:
   a. Check all fuses for continuity.
   b. Confirm input bypass voltage and phase rotation is correct.
   c. Verify control transformer connections are correct for voltages being used.
   d. Assure connections and voltage of the battery string[s].
   e. Battery inspection and certification according to IEEE standards.
4. Unit Start-Up:
   a. Energize control power.
   b. Perform control/logic checks and adjust to meet manufacturer specification.
   c. Verify DC float and equalize voltage levels.
   d. Verify DC voltage clamp and over-voltage shutdown levels.
   e. Verify battery discharge, low battery warning, and low battery shutdown levels.
   f. Verify fuse monitor alarms and system shutdown.
   g. Verify inverter voltages and regulation circuits.
   h. Verify inverter/bypass sync circuits and set overlap time.
   i. Perform manual transfers and returns.
   j. Simulate utility outage at no load.
   k. Verify proper recharge.

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C. Instruct up to 10 operations personnel for minimum of 1 day in maintenance and operation of equipment.

END OF SECTION

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SECTION 26 36 23
BYPASS-ISOLATION AUTOMATIC TRANSFER SWITCHES

PART 1 GENERAL

1.01 SUBMITTALS

A. Action Submittals:

1. Descriptive product information.
2. Dimensional drawings.
3. Control diagrams.
4. Conduit entrance locations.
5. Equipment ratings.
6. Seismic anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.

B. Pre-Shipping Submittals, revised Approval Submittal plus the following:

1. Seismic anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements.
3. Factory test reports.
4. Operation and Maintenance Data: As specified in Section 01 78 23, Operation and Maintenance Data.

C. Record Submittal, Revised Pre-Shipping Submittal Plus As-built Changes: Incorporate as-built changes made by the subcontractor.

1.02 QUALITY ASSURANCE

A. Authority Having Jurisdiction (AHJ):

1. Provide the Work in accordance with NFPA 70, National Electrical Code (NEC). Where required by the AHJ, material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ in order to provide a basis for approval under NEC.
2. Materials and equipment manufactured within the scope of standards published by Underwriters Laboratories, Inc. shall conform to those standards and shall have an applied UL listing mark.

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PART 2 PRODUCTS

2.01 MANUFACTURERS

A. ASCO.

B. Caterpillar.

C. Cummins.

D. Eaton.

E. GE Zenith.

F. Kohler.

G. Schneider Electric (Square D).

2.02 GENERAL

A. Transfer switch to be product of a single manufacturer in order to achieve standardization for appearance, operation, maintenance, spare parts, and manufacturer's service.

B. In accordance with applicable standards of NFPA 70, NEMA ICS 1, NEMA ICS 2, NEMA ICS 6, IEEE C37.90.1, and UL 1008.

C. Transfer switch consisting of inherently double-throw power switch unit with interconnected control module.

D. Rated 100 percent, in amperes, for total system transfer of motor, electric heating, and LED light load.

E. Main and arcing contacts visible for inspection with cabinet door and barrier covers removed.

F. Suitable for 480/277 volts, three-phase, three-wire, grounded-wye electrical service having an available short circuit current at line terminals of 30,000 amperes rms symmetrical.

G. Switch Rating: As noted on the Drawings.

H. Current carrying capacity of arcing contacts shall not be used to determine the transfer switch rating.

I. Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.

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J. Operating Conditions:

1. Ambient Temperature: Maximum 40 degrees C.
2. Equipment to be fully rated without any derating for operating conditions listed above.

2.03 ENCLOSURE

A. Type: Nonventilated NEMA 250, Type 1 with enclosure grounding terminal.

B. Dead front, front accessible floor mounted cabinet with 14-gauge welded steel construction.

C. Continuously hinged single door, with handle and lock cylinder.

D. Finish: Baked enamel applied over rust-inhibiting, phosphated base coating.

1. Exterior and Interior Color: Manufacturer's standard.
2. Unpainted Metal Parts: Plated for corrosion resistance.

2.04 BYPASS-ISOLATION TRANSFER SWITCH

A. Type: Electrically operated, mechanically held, double-throw.

B. Momentarily energized, single-electrically operated mechanism energized from source to which load is to be transferred.

C. Locking mechanism to maintain constant contact pressure.

D. **[A: Mechanical interlock switch to ensure only one of two possible switch positions [B: or] [C: time delay in neutral position].]**

E. Silver alloy contacts protected by arcing contacts.

F. Main and arcing contacts visible when door is open and barrier covers removed.

G. Manual operating handle for transfer in either direction under either loaded or unloaded conditions.

H. Internal control wire connections made with ring or spade type terminals, lock washers, and sleeve type marking labels.

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2.05 CONTROL MODULE

A. Completely enclosed and mounted separately from the transfer switch unit.

B. Microprocessor for sensing and logic control with inherent digital communications capability.

C. Plug-in, industrial grade interfacing relays with dust covers.

D. Connected to transfer switch by wiring harness having keyed disconnect plug.

E. Plug-in printed circuit boards for sensing and control logic.

F. Adjustable solid state undervoltage sensors for all three phases of utility and for one phase of standby source:

1. Pickup 85 to 100 percent nominal.
2. Dropout 75 to 98 percent of pickup setting.

G. Adjustable frequency sensors for standby source:

1. Pickup 90 to 100 percent nominal.
2. Dropout 87 to 89 percent of pickup setting.

H. Control module with adjustable time delays:

1. 0.5- to 6-second engine start delay.
2. 0- to 5-minute load transfer to emergency delay.
3. 0- to 30-minute retransfer to normal delay.
4. 0- to 30-minute unload running time delay.
5. Switch to bypass any of the above time delays during testing.

I. Form-C start contacts, rated 10 amperes, 32-volt dc, for two-wire engine control, wired to terminal block.

J. Exerciser, adjustable in 15-minute increments, 7-day clock to automatically exercise generator without load transfer.

K. In-phase monitor to control transfer when both sources are within acceptable phase angle limits, or adjustable pneumatic type time delay relay for time-delay-in neutral position.

L. Adjustable 0 to 5 minutes time delay relay for engine starting signal.

2.06 METERING INSTRUMENTS

A. Digital power monitor to be connected to load side of transfer switch.

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2.07 INDICATORS

A. Type: LED.

B. Green LED to indicate switch position for utility power source.

C. Red LED to indicate switch position for standby power source.

D. White LED to indicate utility power source is available within parameters established by pickup and dropout settings.

E. Amber lens to indicate standby power source is available within parameters established by pickup and dropout settings.

F. Provide one normally open and one normally closed, 5 amperes, 120-volt contact for remote indication when transfer switch is in either position.

2.08 BATTERY CHARGER

A. See Section 26 32 13.13, Diesel Engine Generator Set.

B. Provide battery charger in bypass-isolation transfer switch enclosure.

C. Install charger indicating lights so they are visible without opening the enclosure door.

2.09 FACTORY TESTS

A. Test to Ensure Correct:

1. Operation of individual components.
2. Sequence of operation.
3. Transfer time, voltage, frequency, and time delay settings.

B. Dielectric strength test per NEMA ICS 1.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer’s instructions.

B. Secure enclosure to floor using anchor bolts of sufficient size and number adequate for specified seismic conditions.

END OF SECTION

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SECTION 26 41 00
FACILITY LIGHTNING PROTECTION

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Lightning Protection Institute (LPI): 175, Standard of Practice.
2. National Fire Protection Association (NFPA):
   a. 70, National Electrical Code (NEC).
   b. 780, Standard for the Installation of Lightning Protection Systems.
3. Underwriters Laboratories, Inc. (UL):
   a. 96, Standard for Lightning Protection Components.
   b. 96A, Standard for Installation Requirements for Lightning Protection Systems.

1.02 DESIGN REQUIREMENTS

A. Provide lightning protection system design for the following structures:

1. Facility 300.
2. Facility 360.
3. Facility 380.
4. Facility 400.

B. Design lightning protection system to comply with all applicable provisions of LPI 175, UL 96, UL 96A, and NFPA 780.

1.03 SUBMITTALS

A. Action Submittals:

1. Lightning protection system plans.
   a. Component locations.
   b. Down conductors.
   c. Connecting conductors.
   d. Bond straps.
   e. Air terminals.
   f. Fittings.
   g. Connectors.
   h. Grounding electrode systems.

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B. Informational Submittals:

1. Field test report.
2. Ground Witness Certification-Form LPI-175A.
3. Post-Installation Certification-Form LPI-175B.
4. UL 96 Master Label “C” Certification.

1.04 QUALITY ASSURANCE

A. Lightning protection system design shall be prepared by an LPI-certified designer or recognized lightning protection manufacturer.

B. Lightning protection system shall be installed under direct supervision of an LPI 175 Certified Master Installer.

C. Inspection of final installation and grounding connection shall be performed by an LPI-certified inspector.

D. Provide the Work in accordance with NFPA 70. Where required by Authority Having Jurisdiction (AHJ), material and equipment shall be labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ in order to provide a basis for approval under NEC.

E. Materials and equipment manufactured within the scope of standards published by Underwriters Laboratories, Inc. shall conform to those standards and shall have an applied UL listing mark.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Materials, equipment, and accessories specified in this section shall be products of:

1. Baca Lightning Protection.
2. Thompson Lightning Protection.
3. VFCLightning Protection.

2.02 GENERAL

A. Complete system shall bear UL 96 Master Label C.

B. System Material: Copper or high copper content, heavy-duty bronze castings, or Aluminum, unless otherwise specified.

C. Material shall comply in weight, size, and composition for the class of structure to be protected as established by NFPA 780.

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2.03 COMPONENTS

A. Air Terminal:

1. Material: Solid copper or solid aluminum rods with tapered or blunt points as required for application.
2. Length: Sufficient to extend minimum 10 inches above object being protected.
3. UL 96 Label B applied to each terminal.

B. Conductors:

1. Lightning System Conductors: Bare medium hard-drawn stranded copper, or stranded aluminum as required for the application**.**
2. Main Down Conductor: Smooth twist stranding:
3. Connecting Conductor: Concentric stranding:
4. Bonding Conductor: Flexible strap.
5. Main down and connecting conductors shall bear the UL 96 Label A, applied every 10 feet.
6. Grounding Conductors: Stranded bare copper.

C. Cable Fastener And Accessories: Capable of withstanding minimum pull of 100 pounds.

D. Fittings:

1. Heavy-duty.
2. Bolts, Screws, and Related Hardware: Stainless steel.

E. Ground Rods: Stainless steel. Length and diameter as required.

F. Grounding Connections:

1. Welds: Exothermic process.
2. Fasteners: Bolted clamp type, corrosion-resistant copper alloy.
3. Hardware: Silicone bronze.

G. Cable Connections and Splicers:

1. Welds: Exothermic process.
2. Fasteners: Bolted clamp type, corrosion-resistant copper alloy.
3. Through-Roof Connectors: Straight or right angle with bronze and lead seal flashing washer.

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H. Accessories: Thompson 265 Vane or approved equal.

I. Conduit: Schedule 40 PVC, as specified in Section 26 05 33, Raceway and Boxes.

PART 3 EXECUTION

3.01 GENERAL

A. Workmanship to comply with all applicable provisions of LPI 175, UL 96, UL 96A, and NFPA 780.

B. Aluminum materials shall be used where required to meet the galvanic corrosion requirements of UL 96A.

C. Provide pitchpockets or method compatible with roofing to waterproof roof penetrations.

D. Install accessory vane on air terminal centered above Facility 300 main entry doorway.

E. Install system in inconspicuous manner so components blend with building aesthetics.

3.02 EXAMINATION

A. Verify conditions prior to installation. Actual conditions may require adjustments in air terminal and ground rod locations.

3.03 INSTALLATION

A. Air Terminals:

1. Supports: Brackets or braces.
2. Parapet Bracket Attachment: Lag or expansion bolts.
3. Secure base to roof surface with adhesive or pitch compatible with roofing bond.
4. Provide terminal flashing at roof penetrations.
5. Perimeter Terminals:
   a. Maximum Spacing: 20 feet.
   b. Maximum Distance From Outside Edge of Building: 2 feet.
6. Roof Ridge Terminals: Maximum spacing 20 feet.
7. Mid-Roof Terminals: Maximum spacing 50 feet.
8. Provide blunt point air terminals for applications exposed to personnel.

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B. Conductors:

1. Conceal whenever practical.
2. Provide 1-inch PVC conduit in building walls or columns for main downleads and roof risers.
3. Support: Maximum spacing for exposed conductors.
    a. Vertical: 3 foot.
    b. Horizontal: 4 foot.
4. Maintain horizontal and vertical conductor courses free from dips or pockets.
5. Bends: Maximum 90 degrees, with minimum 8-inch radius.
6. Install air terminal conductors on the structural roof surface before roofing composition is applied.

C. Bonding:

1. Bond to Main Conductor System:
    a. Roof mounted ventilators, fans, air handlers, masts, flues, cooling towers, handrails, and other sizeable metal objects.
    b. Roof flashing, gravel stops, insulation vents, ridge vents, roof drains, soil pipe vents, and other small metal objects if located within 6 feet of main conductors or another grounded object.
2. Bond each steel column or major framing members to grounding system.
3. Bond each main down conductor to grounding system.

D. Grounding System:

1. Grounding Conductor:
    a. Completely encircle building structure.
    b. Bury minimum 1 foot below finished grade.
    c. Minimum 2 feet from foundation walls.
2. Interconnect ground rods by direct-buried copper cables.
3. Maximum Resistance: 2 ohms when connected to ground rods.
4. Connections:
    a. Install ground cables continuous between connections.
    b. Exothermic welded connections to ground rods, cable trays, structural steel, handrails, and buried and nonaccessible connections.
    c. Provide bolted clamp type mechanical connectors for all exposed secondary connections.
    d. Use bolted offset parapet bases or through-roof concealed base assemblies for air terminal connections.

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e. Provide interconnections with electrical and telephone systems and all underground metal pipes.
f. Provide electric service arrestor ground wire to building water main.

3.04 FIELD QUALITY CONTROL

A. Field Testing:

1. Isolate lightning protection system from other ground conditions while performing tests.
2. Resistance: Test ground resistance of grounding system by the fall-of-potential method.
   a. Test Resistance to Ground: Maximum 2 ohms.
   b. Install additional ground rods as required to obtain maximum allowable resistance.
3. Test Report:
   a. Description of equipment tested.
   b. Description of test.
   c. Test results.
   d. Conclusions and recommendations.
   e. Appendix, including appropriate test forms.
   f. Identification of test equipment used.
   g. Signature of responsible test organization authority.

END OF SECTION

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SECTION 26 42 01
PIPE BONDING AND TEST STATIONS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American National Standards Institute (ANSI).
2. American Water Works Association (AWWA):
   a. C110, Ductile-Iron and Gray-Iron Fittings for Water.
   b. C205, Cement-Mortar Protective Lining and Coating for Steel Water Pipe - 4 in. (100 mm) and Larger - Shop Applied.
   c. C207, Steel Pipe Flanges for Waterworks Service - Sizes 4 in. Through 144 in. (100 mm Through 3,600 mm).
   d. C217, Petrolatum and Petroleum Wax Tape Coatings for the Exterior of Connections and Fittings for Steel Water Pipelines.
3. ASTM International (ASTM):
   a. B418, Standard Specification for Cast and Wrought Galvanic Zinc Anodes.
   b. F436, Standard Specification for Hardened Steel Washers.
4. NACE International (NACE): RP0169, Control of External Corrosion on Underground or Submerged Metallic Piping Systems.
5. National Electrical Manufacturers Association (NEMA):
   a. WC 70, Nonshielded Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy.
6. NSF International (NSF).
7. The Society for Protective Coatings (SSPC):
   a. SP 1, Solvent Cleaning.
   b. SP 10, Near-White Blast Cleaning.

1.02 DEFINITIONS

A. Electrical Isolation: Condition of being electrically isolated from other metallic structures (including, but not limited to, piping, reinforcement, casings) and the environment as defined in NACE RP0169.

B. Electrically Continuous Pipeline: Pipeline that has a linear electrical resistance equal to or less than the sum of the resistance of the pipe plus the maximum allowable bond resistance for each joint as specified in this section.

C. Ferrous Metal Pipe: Pipe made of steel or iron, or pipe containing steel or iron as a principal structural material, except reinforced concrete pipe.

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D. Foreign-Owned: Buried pipe or cable not specifically owned or operated by Owner.

E. Lead, Lead Wire, Joint Bonds, Pipe Connecting Wires, Cable: Insulated copper conductor; the same as wire.

1.03 SUBMITTALS

A. Action Submittals: Catalog cuts and information for products proposed for use.

B. Informational Submittals:

1. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements.
2. Field Test Reports, including results of insulator testing.
3. Qualifications of Cathodic Protection Specialist.

1.04 QUALITY ASSURANCE

A. Cathodic Protection Specialist Qualifications: NACE International certified.

1.05 SCHEDULING

A. Specified weld-in fittings may have long delivery times; contact manufacturers and obtain commitments for delivery before scheduling installation.

PART 2 PRODUCTS

2.01 WIRES

A. Conform to applicable requirements of NEMA WC 70.

B. Joint Bond:

1. General: Single-conductor, stranded copper wire with 600-volt HMWPE insulation. Supply joint bonds complete with formed copper sleeve on each end of wire.
2. Push-On, Mechanical, or Flanged Joints: 2 AWG wires, 18 inches long.
3. Flexible Coupling Joints: 2 AWG wires, 24 inches long, with two 12-inch-long THHN or XHHW insulated 12 AWG wire pigtails, as manufactured by Erico Products Inc. (Cadweld), Cleveland, OH.
4. Insulated Flexible Coupling Joints: 8 AWG wire, 18 inches long, with one 12-inch-long THHN or XHHW insulated 12 AWG wire pigtail.

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C. Wire Labels:

1. Materials shall be suitable for permanent identification.
2. Plastic, paper, or cloth markers will not be permitted.
3. Each pipe test wire shall include pipe diameter and pipe type, reference electrode, casing, or galvanic anode, as applicable.

2.02 THERMITE WELD MATERIALS

A. General:

1. Thermite weld materials consist of wire sleeves, welders, and weld cartridges according to weld manufacturer's recommendations for each wire size and pipe or fitting size and material.
2. Welding materials and equipment shall be product of a single manufacturer. Interchanging materials of different manufacturers is not acceptable.

B. Molds: Graphite; ceramic "One-Shot" molds not acceptable.

C. Adapter Sleeves:

1. For 12 AWG and 2 AWG wires.
2. Prefabricated factory sleeve joint bonds or bond wires with formed sleeves made in field are acceptable. Attach field-formed joint bond sleeves with appropriate size and type of hammer die furnished by thermite weld manufacturer.
3. Extend wire conductor 1/4 inch beyond end of sleeve.

D. Cartridges: Cast-iron thermite weld cartridges for cast and ductile iron pipe and fittings.

1. Maximum Cartridge Size: 25 grams for steel and 32 grams for cast and ductile iron materials, respectively.

E. Welders and Cartridges: For attaching copper wire to pipe material:

Pipe Material	**Weld Type**	**Cartridge Size, Max.**
4 AWG Wire and Smaller:		
Steel	HA, VS, HC	25 gm
Ductile Iron	HB, VH, HE	32 gm
Cast Iron	HB, VH, HE	32 gm

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Pipe Material	Weld Type	Cartridge Size, Max.
2 AWG Joint Bonds:		
Steel	FS	25 gm
Ductile or Cast Iron	FC	32 gm
Concrete Cylinder Pipe	HA, GR	32 gm

F. Welding Materials Manufacturers:

1. Erico Products Inc. (Cadweld), Cleveland, OH.
2. Continental Industries, Inc. (Thermo-Weld), Tulsa, OK.

G. Thermite Weld Coating:

1. Thermite Weld Caps: Prefabricated weld cap with coating and suitable primer, such as Handy Cap II with Royston Primer 747, as manufactured by Royston Laboratories, Inc. or Engineer approved equal.
2. Where space is limited on fittings, insulated resin may be used in lieu of Thermite Weld Caps. Insulating Resin: 100 percent solids epoxy that can cure in submerged or buried conditions. At Contractor's option, bitumastic coating (Carboline Bitumastic 50 or equal) may be used if it is allowed to dry completely before covering.
3. Use products recommended by pipe or fitting coating manufacturer to repair spot damage at thermite weld connections not covered by standard pipeline coating repair procedure or thermite weld cap.

2.03 ANCILLARY MATERIALS

A. Mastic Coating: TC Mastic (Brush Applied) as manufactured by Tapecoat Co., Evanston, IL.

B. Wire Connectors: One-piece, tin-plated crimp-on lug connector as manufactured by Burndy Co. or Thomas and Betts.

C. Compression Connectors:

1. For in-line, tap, and multisplice furnish "C" taps made of conductive wrought copper, sized to fit wires being spliced.
2. Manufacturer and Product: Burndy; Type "YC."

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D. Electrical Tape:

1. Linerless rubber high-voltage splicing tape and vinyl electrical tape suitable for moist and wet environments.
2. Manufacturer and Products: 3M Products; Scotch 130 C and Scotch 88.

2.04 INSULATING JOINTS

A. Reference Section 40 27 00, Process Piping—General, and Drawings for insulating joints.

PART 3 EXECUTION

3.01 INSTALLATION

A. For non-metallic pipe fittings, connect all adjacent pipe fittings with pipe joint bonds to form an electrically continuous pipe section. Any pipe fittings with PVC pipe between the fittings will not require joint bonding.

3.02 PIPE JOINT BONDING

A. Electrically bond joints of buried steel and iron pipe, including vault and manhole piping and fittings, and including restrained joints, except joints specified to be threaded, welded, or insulated.

B. Install two joint bond wire per pipe joint for pipe larger than inch diameter (includes 12-inch diameter) and one bond wire for pipe less than 12-inch diameter.

C. Use thermite weld process for electrical connection of wires to pipe and fittings.

D. Test each bonded joint for continuity.

E. Joint bonds for cast-iron soil pipe and fittings and high silicon cast-iron pipe and fittings shall be in accordance with manufacturer’s recommendations. Bronze wedges are not an acceptable method of achieving electrical continuity.

3.03 WIRE CONNECTIONS

A. Thermite Weld:

1. Use thermite weld method for electrical connection of copper wire to steel, ductile, and cast-iron surfaces. Observe proper safety precautions, welding procedures, thermite weld material selection, and surface preparation recommended by welder manufacturer. Ensure that pipe or

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fitting wall thickness is of sufficient thickness that thermite weld process will not damage integrity of pipe or fitting wall or protective lining.

2. After weld connection has cooled, remove slag, visually inspect, and physically test wire connection by tapping with a hammer; remove and replace defective connections.
3. On pipe and fittings with dielectric linings, make weld connection on shop tab provided or on a thick metal section to minimize damage to lining and coating. After weld is made, coat weld with coating repair material.
4. Install prefabricated thermite weld cap over each completed connection. Repair exposed metal surfaces not covered by thermite weld cap in accordance with coating manufacturer's recommendations. Repair damage to pipe lining in accordance with lining applicator's recommendations. For thermite weld connections to pipe, apply insulating resin, then specified joint coating at each completed connection. Repair exposed metal surfaces not covered by resin or pipe coating in accordance with coating manufacturer's recommendations.
5. Make wire connections to concrete cylinder pipe by thermite welding to shop welded steel studs or plates provided on pipe for this purpose. Clean steel studs to bright metal before thermite welding. Coat completed wire connection with cement mortar.

3.04 WIRE INSULATION REPAIR

A. Handle wires with care. Splices for damage to wire insulation shall be required by spirally wrapping (50 percent overlap, minimum) with two coats of high-voltage rubber splicing tap and two layers of vinyl electrical tape. Make wire splices with suitable sized compression connectors or mechanically secure and solder with rosin cored 50/50 solder. Splices shall be approved by Engineer.

3.05 INSULATED JOINTS

A. Install insulated joints to electrically isolate pipeline from other structures as specified in Section 40 27 00, Process Piping—General. Locate insulated joints at connections to existing metallic pipe, where cathodically protected pipe connects to pipe not intended to have cathodic protection, where dissimilar metals join and where shown.

B. Align and install insulating joints as shown on Drawings and according to manufacturer's recommendations.

C. Do not use fastener lubricants that contain graphite or metallic compounds that will interfere with the insulating capability of the completed joint.

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D. Test the completed insulating joint as specified herein.

E. Insulating Flange Lining and Coating:

1. After assembly of insulated flanges, repair coatings and linings as shown on Drawings and as specified herein.
    a. Interior Lining: Repair linings as specified by manufacturer**.** For cement mortar linings, prepare cement-mortar surface in accordance with paint manufacturer's instructions and apply a 20-mil minimum thickness of NSF potable water approved, 100 percent solids water or air curing epoxy coating to interior of pipeline. Apply coating for a minimum of two pipe diameter lengths from insulating flange in both directions. Apply and cure coating in accordance with manufacturer's recommendations. Do not apply coating where it will interfere with operation of pipeline valves or other pipeline assemblies.
    b. Exterior Coating: For buried insulating flanges, coat completed joint with petroleum wax tape in accordance with AWWA C217**.**

3.06 FIELD QUALITY CONTROL

A. Electrical Continuity Testing:

1. Provide necessary equipment and materials, and make electrical connections to pipe as required to test continuity of bonded joints.
2. Conduct continuity test on buried joints that are required to be bonded. Test electrical continuity of joint bonds after bonds are installed but before backfilling of pipe.
3. Have Cathodic Protection Specialist monitor tests of bonded joints.
4. Test electrical continuity of completed joint bonds using either a digital low resistance ohmmeter or by Calculated Resistance Method, at Contractor's option.
    a. Digital Low Resistance Ohmmeter Method:
        1) Provide the following equipment and materials:
            a) One Biddle Model 247001 digital low resistance ohmmeter.
            b) One set of duplex helical current and potential hand spikes, Biddle Model No. 241001, cable length as required.
            c) One calibration shunt rated at 0.001 ohm, 100 amperes, Biddle Model No. 249004.
        2) Test Procedure:
            a) Measure resistance of joint bonds with low resistance ohmmeter in accordance with manufacturer's written instructions.

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b) Use helical hand spikes to contact pipe on each side of joint, without touching thermite weld or bond.
c) Clean contact area to bright metal by filing or grinding and without surface rusting or oxidation.
d) Record measured joint bond resistance on test form described herein.
e) Repair damaged pipe coating.

b. Calculated Resistance Method:
1) Provide the following equipment and materials:
a) One dc ammeter (meter or clamp-on) with full scale reading of 100 amperes and a minimum resolution of 1 ampere or a 100-ampere shunt with a voltmeter as specified herein.
b) One high resistance electronic voltmeter with a dc low range of 200 millivolts full scale to a dc high range of 20 volts full scale and capable of a minimum resolution of 1 millivolt (two voltmeters are required if a shunt is used).
c) One knife switch, safety switch, or time controlled relay suitable for test current.
d) Two electrical probes for the voltmeter.
e) Insulated wire suitable for carrying the test current, length as required.
f) One dc power supply with a steady capacity of 50 amperes minimum; storage batteries are not an acceptable power supply.
g) Test Procedure: Either tightly clamp or thermite weld current wire connections to the pipe. Determine wire size for the test current, and do not exceed 1,000 feet in length.

c. Apply a minimum direct current of 50 amperes.
d. Measure voltage drop across each joint with voltmeter by contacting pipe on each side of joint. Voltmeter connections to bond wire or thermite welds will not be acceptable.
e. Measure current applied to test span and voltage drop across joint simultaneously.
f. Record measured voltage drop and current for each joint of test form described herein and calculate bond resistance in accordance with the following formula:

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$$R = \frac{E}{I}$$

Where:

R = Resistance of the joint bond.
E = Measured voltage drop across the joint, in volts.
I = Test current applied to the pipe test span, in amperes.

5. Joint Bond Acceptance:
   a. Joint Bond Resistance: Less than or equal to the maximum allowable bond resistance values in Table 1.

Table 1

Joint Type	Max. Allowable Resistance	
	1 Bond/Joint	2 Bonds/Joint
Push-On or Mechanical	0.000325 ohm	0.000162 ohm
Flexible Coupling	0.000425 ohm	0.000212 ohm
Concrete Cylinder	0.000200 ohm	0.000100 ohm

   b. Replace joint bonds that exceed the allowable resistance. Retest replacement joint bonds for compliance with bond resistance.
   c. Repair defective joint bonds discovered during energizing and testing.
6. Record Tests of Each Bonded Pipeline:
   a. Description and location of pipeline tested.
   b. Starting location and direction of test.
   c. Date of test.
   d. Joint type.
   e. Test current and voltage drop across each joint and calculated bond resistance (Calculated Resistance Method only).
   f. Measured joint bond resistance (Digital Low Resistance Ohmmeter method only).
   g. Record test information on a form that includes information listed above.

B. Insulated Joint Testing:

1. Provide Engineer with 3 days' advance notice before beginning tests.
2. Cathodic Protection Specialist shall monitor the tests.
3. Test each joint after assembly with insulator tester in accordance with manufacturer's written instructions.
4. For insulating flanges, test and record insulating values of each bolt in addition to the completed flange.
5. Replace damaged or defective insulation parts.
6. Correct defects identified during testing.

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3.07 SUPPLEMENT

A. The supplement listed below, following “End of Section,” are a part of this Specification.

1. Joint Bond Continuity Test Schematic.

END OF SECTION

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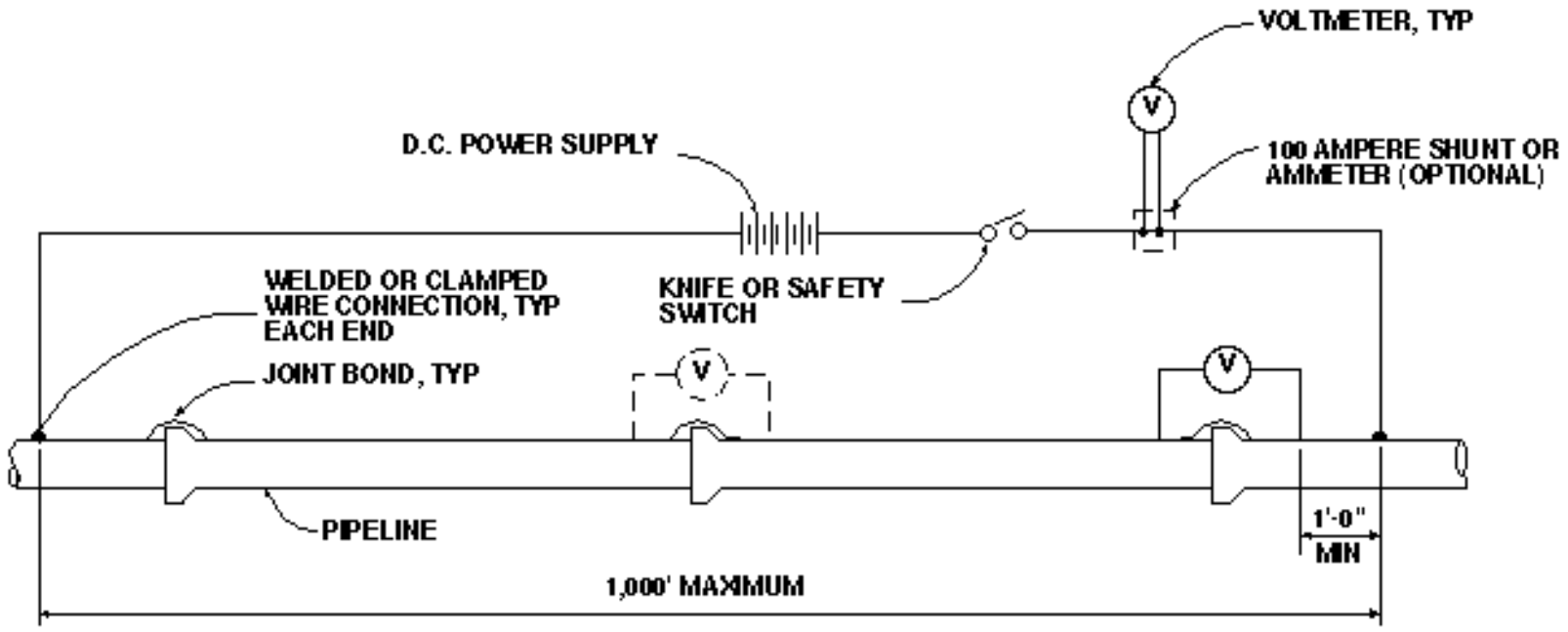

JOINT BOND CONTINUITY TEST SCHEMATIC

DTE195.SP 1Q4-17-95/mbb

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SECTION 26 42 02
GALVANIC ANODE CATHODIC PROTECTION SYSTEM

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   a. B418, Standard Specification for Cast and Wrought Galvanic Zinc Anodes.
   b. B843, Standard Specification for Magnesium Alloy Anodes for Cathodic Protection.
   c. G97, Standard Test Method for Laboratory Evaluation of Magnesium Sacrificial Anode Test Specimens for Underground Applications.
2. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).

1.02 DEFINITIONS

A. Ferrous Metal Pipe: Pipe made of steel or iron, and pipe containing steel or iron as a principle structural material, except reinforced concrete.

B. Lead, Lead Wires, Joint Bonds, Cable: Insulated copper conductor; the same as wire.

C. Pipe Section: A single fitting or a single piece of pipe less than 20 feet in length. Pipe Sections between 20 feet and 40 feet in length shall be treated as two Pipe Sections. Each 20 feet of pipe and fittings with joint bonds may be treated as one Pipe Section.

1.03 SUBMITTALS

A. Action Submittals: Catalog cuts and other information for products to be used.

B. Informational Submittals:

1. Compliance Statement: Provide compliance statement that galvanic anode composition meets chemical requirements specified herein.
2. Biweekly reports for pipe-to-soil potential measurements and field summary reports for at least 10 percent of all anode installations.
3. Cathodic Protection Specialist qualifications.

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1.04 QUALITY ASSURANCE

A. Cathodic Protection Specialist Qualifications: National Association of Corrosion Engineers (NACE) certified.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Packing and Shipping: Provide electrode packaged in a plastic or heavy paper bag of sufficient thickness to protect electrode, backfill, and cloth bag during normal shipping and handling.

B. Store prepackaged anodes off the ground and keep them dry. Protect against weather, condensation, and mechanical damage. Immediately remove wet or mechanically damaged prepackaged anodes from Site. Handle anodes with care to prevent loss of backfill material. Do not lift or hold anodes by lead wire.

PART 2 PRODUCTS

2.01 GALVANIC ANODES

A. Zinc Anodes:

1. Composition: ASTM B418, Type I or ASTM B418, Type II.
2. Dimensions:
   a. Length: 9 inches minimum.
   b. Bare Weight: 5 pounds minimum.

B. Anode Wire: Furnish each anode with 12 AWG stranded copper wire with TW or THWN insulation, 10 feet long.

C. Wire-to-Anode Connection: Manufacturer’s standard. Anode connection shall be stronger than the wire.

D. Backfill:

1. Composition:
   a. Ground Hydrated Gypsum: 75 percent.
   b. Powdered Wyoming Bentonite: 20 percent.
   c. Anhydrous Sodium Sulfate: 5 percent.
2. Grain Size: 100 percent passing through a 20-mesh screen and 50 percent retained by a 100-mesh screen.
3. Mixture: Thoroughly mixed and firmly packaged around galvanic anode within cloth bag by means of adequate vibration.
4. Quantity of backfill shall be sufficient to cover surfaces of anode to a depth of 1 inch.

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2.02 CATHODIC PROTECTION TEST STATION

A. Test stations will not be required for this project.

2.03 THERMITE WELD MATERIALS

A. General:

1. Thermite wire sleeves, welders, and weld cartridges according to manufacturer's recommendations for each wire size, pipe or fitting size, and material.
2. Welding materials and equipment shall be the product of a single manufacturer. Interchanging materials of different manufacturers will not be acceptable.

B. Molds: Graphite. Ceramic "One-Shot" molds are not acceptable.

C. Cartridges:

1. Cast-iron thermite weld cartridges for cast and ductile iron pipe and fittings.
2. Maximum Cartridge Size:
   a. 25 grams for steel material.
   b. 32 grams for cast and ductile iron materials.

D. Welding Materials Manufacturers:

1. Erico Products Inc. (Cadweld), Cleveland, OH.
2. Continental Industries, Inc. (Thermo-Weld), Tulsa, OK.

E. Thermite Weld Caps:

1. Prefabricated weld cap with coating and suitable primer.
2. Handy Cap II with Royston Primer 747, as manufactured by Royston Laboratories, Inc.

2.04 COATING REPAIR MATERIAL FOR PIPE AND FITTINGS

A. As recommended by pipe or fitting coating manufacturer for spot damage at thermite weld connections not covered by standard pipeline coating repair procedure or thermite weld cap.

B. Material: 100 percent solids epoxy that cures in submerged or buried conditions.

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C. Manufacturers and Products:

1. Carboline, St. Louis, MO; Carboguard A-788 Splash Zone Mastic.
2. Raven Linings, Tulsa, OK; Aquatapoxy A-7.

PART 3 EXECUTION

3.01 GENERAL

A. Construct galvanic anode cathodic protection system on buried steel, ductile iron and cast iron, pipe appurtenances, and fittings used in conjunction with nonmetallic pipe. Galvanic anode cathodic protection system shall also protect protruding metallic pipe from concrete encasement.

B. Conform to NFPA 70.

3.02 GALVANIC ANODE INSTALLATION

A. General:

1. Install anodes on every metallic pipe appurtenance and on every metallic pipe stub protruding from concrete encasement.
2. Number of anodes shall be provided based on the Table in the Buried Pipe Appurtenances paragraph in this Section. For pipe stubs that extend more than 5 feet, double the required anodes in the Table.
3. Thoroughly compact earthfill around each anode to a point 1 foot above anode. Stop backfill below grade to allow for placing of topsoil, when required.
4. Provide minimum anode spacing of 2 feet from other unprotected pipelines.
5. Bury anode wires a minimum of 24 inches below finish grade.

3.03 BURIED PIPE APPURTENANCES

A. Each buried cast iron or steel fitting, Pipe Section, and appurtenance used in conjunction with nonmetallic pipe shall be cathodically protected with zinc anodes. Where two or more metallic fittings are adjacent to each other, install joint bonds as specified in Section 26 42 01, Pipe Bonding and Test Stations, and install specified quantity of zinc anodes on each fitting, Pipe Section, or appurtenance.

B. Use thermite weld method for zinc anode connections to cast iron or steel fittings and appurtenances.

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C. Equally space zinc anodes around fitting, metallic pipe sections, or appurtenance a minimum of 2 feet from metallic fitting, at bottom edge of pipeline trench. Number of anodes to be installed on each cast iron or steel fitting, Pipe Section, or appurtenance:

Pipe Size	No. of Anodes
16" or less	1
18" to 30"	2
32" to 48"	3
48" or larger	4

D. At Contractor's option, larger anodes may be used in place of multiple smaller anodes for a group of bonded metallic components, provided that same total weight of zinc is used.

E. For pipe and fittings with fusion bonded epoxy coatings, anode requirements shall be reduced by one pipe size.

3.04 WIRE CONNECTIONS TO PIPE

A. Make electrical connection of copper wire to steel, ductile, and cast iron surfaces using thermite weld method. Observe proper safety precautions, welding procedures, thermite weld material selection, and surface preparation as recommended by manufacturer. Assure pipe or fitting wall thickness is of sufficient thickness that thermite weld process will not damage integrity of pipe or fitting wall or protective lining.

B. Before connection is made, clean surface to bare metal by making a 2-inch by 2-inch window in coating, and then filing or grinding surface to produce a bright metal finish. Grinding shall be with a vitrified type grinding wheel; use of resin, rubber, or shellac impregnated type grinding wheels is not acceptable. Prepared metal surface shall be dry.

C. Install wire sleeves on the ends of the wires before welding to metal surface. Perform thermite welding in strict accordance with manufacturer's written instructions. After weld connection has cooled, remove slag and physically test wire connection by tapping with a hammer; remove and replace defective connections.

D. Install prefabricated thermite weld cap over each completed connection. Repair exposed metal surfaces not covered by thermite weld cap in accordance with coating manufacturer's recommendations. Repair damage to pipe lining in accordance with lining applicator's recommendations.

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3.05 WIRE INSULATION REPAIR

A. Repair splices or damage to wire insulation by spirally wrapping (50 percent overlay, minimum) with two coats of splicing tape and two layers of vinyl electrical tape. Make wire splices with suitable sized compression connectors or mechanically secure and solder with rosin cored 50/50 solder. Splices shall be approved by Engineer.

3.06 FIELD TESTING

A. Provide Cathodic Protection Specialist to visit Site during installation of galvanic anode cathodic protection system. Cathodic Protection Specialist shall witness installation of at least 10 percent of anodes and provide pipe-to-soil potential measurements to ensure proper installation. Cathodic Protection Specialist shall provide biweekly reports with pipe-to-soil potential measurements and a summary report of the inspection performed. Pipe fittings and pipe appurtenances will be tested at random and if any fail testing, all pipe fittings and appurtenances will be subject to inspection. Cathodic Protection Specialist shall be responsible to ensure compliance with these Specifications, and for observation and testing services.

END OF SECTION

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SECTION 26 43 00
SURGE-PROTECTIVE DEVICES, 1000 VOLTS AND BELOW

PART 1 GENERAL

1.01 SUBMITTALS

A. Submit product data on each surge-protective device (SPD), indicating component values, part numbers, and conductor sizes. Include dimensional drawing for each, showing mounting arrangements.

B. Submit manufacturer's UL certified test data and nameplate data for each SPD.

C. Submit electrical single-line diagram showing location of each SPD.

1.02 QUALITY ASSURANCE

A. UL Compliance and Labeling:

1. For power and signal circuits, SPD devices shall comply with UL 1449 and complimentary listed to UL 1283 as an electromagnetic interference filter. Provide units that are listed and labeled by UL.
2. For telephone circuit protection, SPD devices shall comply with UL 497A.

B. ANSI Compliance: Use SPD devices in compliance with the recommendations of IEEE C62.41.1, IEEE C62.41.2, and IEEE C62.45.

PART 2 PRODUCTS

2.01 GENERAL

A. SPD devices to be installed in low-voltage switchgear, switchboards, motor control centers and panelboards to be provided by the equipment manufacturer.

B. SPD devices to be installed as a part of the lightning protection systems to be provided as required by Section 26 41 00, Facility Lightning Protection.

C. SPD devices shall be capable of performance at ambient temperatures between minus 40 degrees C and 60 degrees C, at relative humidity ranging from 0 percent to 95 percent, and at altitudes ranging from sea level to 12,000 feet.

D. SPD devices shall be fused to disconnect the suppressor from the electrical source should the suppressor fail. The fusing shall allow full surge handling

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capabilities and to afford safety protection from thermal overloads and short circuits.

E. Design SPD devices for the specific type and voltage of the electrical service. Single-phase and three-phase wye-configured systems shall have L-N, L-G, and N-G protection. Grounded delta-configured systems shall have L-L and L-G protection.

F. Power Filter: The SPD shall include a high frequency extended range power filter complimentary listed to UL 1283 as an electromagnetic interference filter.

2.02 MAIN DISTRIBUTION SPD

A. Provide SPD meeting IEEE C62.41.1 and IEEE C62.41.2 Location in accordance with Category C.

B. Surge current capacity shall be not less than the following:

1. L-N Capacity: 200 kA.
2. L-G Capacity: 120 kA.
3. N-G Capacity: 120 kA.

C. Suppressor housing shall be in an enclosure that has the same NEMA rating as the equipment it protects and painted to match.

D. UL 1449 maximum suppression voltage shall not be more than:

System Voltage	Phase	L-L or L-N Suppression Voltage
120	1	400
208Y/120	3	400
240	3	800
480Y/277	3	800

2.03 PANELBOARD SPD

A. Provide SPD meeting IEEE C62.41.1 and IEEE C62.41.2 Location Category B.

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B. Surge current capacity shall be not less than the following:

1. L-L Capacity: 80 kA.
2. L-N Capacity: 80 kA.
3. L-G Capacity: 80 kA.
4. N-G Capacity: 80 kA.

C. Suppressor shall be in an enclosure that has the same NEMA rating as the panel it protects or the SPD may be integral to a panelboard.

D. UL 1449 maximum clamp voltage shall not be more than:

System Voltage	Phase	L-L or L-N Clamp Voltage
120	1	400
208Y/120	3	400
240	3	800
480Y/277	3	800

2.04 ANNUNCIATION

A. Provide unit or separately mounted LED-type indication lights to show the normal and failed status of each module. Provide one normally open and one normally closed contacts which operate when the unit fails.

2.05 SURGE COUNTER

A. Provide each SPD rated above 100 kA with a counter displaying the number of voltage transients that have occurred on the unit input. The counter shall be battery backed and retain the count through system power outages.

2.06 PAIRED CABLE DATA LINE INTERIOR SUPPRESSORS

A. Provide units meeting IEEE C62.41, Location Category A.

B. Use bi-polar 1,500-watt silicon avalanche diodes between the protected conductor and earth ground.

C. Provide units with a maximum single impulse current rating of 80 amperes (10 by 1,000 microsecond-waveform).

D. Breakdown voltage shall not exceed 36 volts.

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2.07 PAIRED CABLE DATA LINE EXTERIOR SUPPRESSORS

A. Provide units meeting IEEE C62.41, Location Category A.

B. Suppressors shall be a hybrid design with a minimum of three stages, utilizing solid-state components and operating bi-directionally.

C. Suppressors shall meet or exceed the following criteria:

1. Maximum single impulse current rating of 10,000 amperes (8 by 20 microsecond-waveform).
2. Pulse Life Rating: 3,000 amperes (8 by 20 microsecond-waveform): 2,000 occurrences.
3. Maximum clamping voltage at 10,000 amperes (8 by 20 microsecond current waveform), shall not exceed the peak of the normal applied signal voltage by 200 percent.

PART 3 EXECUTION

3.01 APPLICATION REQUIREMENTS

A. Install SPD when indicated on the Drawings and:

1. Main Distribution SPD in or near each low-voltage switchgear (load center).
2. Main Distribution SPD in or near each motor control center.
3. Panelboard SPD In or near each panelboard that is the first panelboard in a separately-derived system.

B. Electronic Equipment Paired Cable Conductors: Install data line suppressors at the low voltage input and output of each piece of equipment, including telephone cable entrance.

1. Use secondary protectors on lines that do not exit the structure.
2. Use primary protectors on lines that exit and enter the structure.

3.02 GENERAL INSTALLATION REQUIREMENTS

A. Install suppressors according to manufacturer’s recommendations.

B. Install suppressors directly to the cabinet which houses the circuit to be protected so that the suppressor leads are straight and short, with all conductors laced, running directly to the point of connection within the panel, without loops or bends. If bends are unavoidable, no bend may exceed 90 degrees and bending radius may not be less than 6 inches.

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C. Connecting wires shall be as short as possible with gently twisted conductors, tied together, to prevent separation. Connecting wires shall not exceed 24 inches in length at any point.

D. Field installed conductors shall be the same as specified for building wire, not smaller than No. 8 AWG and not larger than No. 4 AWG. Device leads shall not be longer than the length recommended by the manufacturer, unless specifically reviewed and approved by the manufacturer.

E. Provide dedicated disconnecting means for SPD devices installed at main service entrance location, switchgear, and motor control centers. Provide dedicated 30-60-ampere circuit breakers (size dependent upon wire size used) with number of poles as required, as disconnecting means for SPD devices installed at panelboards. The interrupting capacity of the circuit breakers shall be that specified for the other breakers at that location.

END OF SECTION

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SECTION 26 50 00
LIGHTING

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   a. A123/A123M, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   b. A153/A153M, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
   c. A572/A572A, Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel.
   d. A588/A588M, Standard Specification for High-Strength Low-Alloy Structural Steel, with 50 ksi [345 MPa] Minimum Yield Point to 4-in. [100-mm] Thick.
   e. A595/A595M, Standard Specification for Steel Tubes, Low-Carbon or High-Strength Low-Alloy, Tapered for Structural Use.
   f. A615/A615M, Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
   g. A1011/A1011M, Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength.
   h. D6576, Standard Specification for Flexible Cellular Rubber Chemically Blown.
   i. G154, Standard Practice for Operating Fluorescent Light Apparatus for UV Exposure of Nonmetallic Materials.
2. American Wood Protection Association (AWPA): M6, Brands Used on Forest Products.
3. Canadian Standards Association (CSA).
4. Certified Ballast Manufacturer (CBM).
5. Federal Communications Commission (FCC).
6. Illuminating Engineering Society of North America (IESNA).
   a. HB-9, Lighting Handbook.
   b. LM-79, IES Electrical and Photometric Measurements of Solid-State Lighting Products.
   c. LM-80, IESNA Approved Method for Measuring Lumen Maintenance of LED Light Sources.
   d. RP (Recommended Practices) Series.
   e. TM-21, Projecting Long Term Lumen Maintenance of LED Light Sources.

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7. Institute of Electrical and Electronics Engineers (IEEE): C62.41, Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits.
8. National Electrical Manufacturers Association (NEMA):
9. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
10. ICS 6, Industrial Control and Systems: Enclosures.
11. National Energy Policy Act.
12. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC) – Softbound Version.
13. Rural Utilities Service (RUS): 1728F-700, Specification for Wood Poles, Stubs and Anchor Logs.
14. Underwriters Laboratories, Inc. (UL):
    a. 773, UL Standard for Safety Plug-In Locking Type Photocontrols for Use with Area Lighting - Fourth Edition; Reprint with Revisions Through and Including March 08, 2002.
    b. 844, Electric Lighting Fixtures for Use in Hazardous (Classified) Locations.
    c. 924, Emergency Lighting and Power Equipment.
    d. 1598, UL Standard for Safety Luminaires.
    e. 2108, UL Standard for Safety Low Voltage Lighting Systems - First Edition; Reprint with Revisions through and Including February 24, 2014.
    f. 8750, UL Standard for Safety Light Emitting Diode (LED) Equipment for Use in Lighting Products - First Edition; Reprint with Revisions Through and Including April 1, 2015.
15. U.S. Environmental Protection Agency and U.S. Department of Energy: Energy Star.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
    a. General:
        1) Provide catalog data sheets and pictures for all products listed below.
        2) Proposed Luminaire Substitutions (Interior and Exterior): Provide an electronic photometric file in standard '.ies' file format per the Illumination Engineering Society of North America (IESNA) for any proposed luminaire substitution not identified on the project Luminaire Schedule. Obtain file from the luminaire manufacturer or approved independent photometric testing laboratory. Include the proposed substitute luminaire with all options identified on the project Luminaire Schedule.

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b. Interior Luminaires:
   1) Catalog data sheets with pictures.
   2) Luminaire material, finish, dimensions, and metal gauge.
   3) Lens material, pattern, and thickness.
   4) Candle power distribution curves in two or more planes.
   5) Candle power chart 0 degree to 90 degrees.
   6) Lumen output chart.
   7) Average maximum brightness data in foot lamberts.
   8) Coefficients of utilization for zonal cavity calculations.
   9) Mounting or suspension details.

c. Exterior Luminaires:
   1) Catalog data sheets with pictures. Luminaire material, finish, dimensions, and metal gauge.
   2) Lens material, pattern, and thickness. Filters.
   3) IESNA lighting classification (BUG rating).
   4) Isolux diagram.
   5) Lighting distribution data and lighting distribution classification type as defined in IESNA HB 9.
   6) Fastening details to wall, pendant, or pole.
   7) Ballast type, location, and method of fastening.
   8) For light poles, submit catalog sheet, wind loading, pole deflection with fixture attached, total weight, all accessories, complete dimensions, and finish.
   9) Documentation for Energy Star qualifications for equipment provided under this section.
   10) Brackets and supports.
   11) Pole foundations.

d. Lamps:
   1) Voltages.
   2) Watts.
   3) Correlated Color Temperature (CCT).
   4) Color Rendering Index (CRI).
   5) Published rated life (in hours). Provide number of hours per start and operating temperature for published rated life hours indicated.
   6) Published rated initial and mean lumens.
   7) Lumen maintenance curve.
   8) Lamp type (ANSI designation, dimensions, shape, and base).

e. Ballasts:

f. LED Source Systems:
   1) General:
      a) IESNA LM-80 test reports.
      b) IESNA TM-21 ratings.
      c) Operating temperature range. Data sheet (chart/graph) describing life as a function of temperature.

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d) Warranty: Light engine and driver.
e) Rated life.
f) Surge protection.
g) Thermal control device, heat sink.
h) Enclosure and wiring information.
i) Operating voltage range.

2) Electronic Module/Light Engine:
a) Correlated Color Temperature (CCT).
b) Color Rendering Index (CRI).

3) Drivers:
a) Input Current Total Harmonic Distortion.
b) Power factor.
c) Sound rating.

g. Time Switches:
1) Wiring diagram.
2) Contact ratings.
3) Functional features.
4) Programmable capabilities.
5) Enclosure type, dimensions.

h. Lighting Contactor:
1) Type (mechanically or electrically held).
2) Enclosure.
3) Contact ratings and configuration.
4) Coil operating voltage.

i. Photoelectric Switches (Photocells):
1) Voltage.
2) Power consumption.
3) Load capacity (watts).
4) Contact ratings and configuration.
5) Time delay.
6) Light operating level controls.
7) Enclosure type and dimensions.
8) Mounting type.
9) Temperature range.
10) Features and options.

j. Photo Sensors/Controls for Daylight Harvesting Control:
1) System description, overall functionality.
2) Each component.
3) Electrical ratings (voltage, amperage, watts).
4) Wiring diagrams.
5) Programming.
6) Testing.

k. Wall box dimmers.

l. Dimming systems.

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m. Occupancy Sensors:
    1) Type.
    2) Switching capacity.
    3) Coverage.
    4) Time delay AUTO/OFF adjustment.
n. Outdoor Motion Sensors.
o. Landscape Lighting:
    1) Luminaires.
    2) Controls.
    3) Transformers.
    4) Wiring.

B. Informational Submittals:

1. Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Manufacturer's printed installation instructions.
3. Operation and Maintenance Data as specified in Section 01 78 23, Operation and Maintenance Data.

1.03 QUALITY ASSURANCE

A. Authority Having Jurisdiction (AHJ):

1. Provide Work in accordance with NFPA 70, National Electrical Code (NEC). Where required by the AHJ, provide material and equipment labeled or listed by a nationally recognized testing laboratory or other organization acceptable to the AHJ to provide a basis for approval under NEC.
2. Provide materials and equipment manufactured within the scope of standards published by Underwriters Laboratories, Inc. in conformance with those standards and with an applied UL listing mark.

B. Standard Products:

1. Provide materials and equipment of manufacturers regularly engaged in the production of products specified in this section and that are of equal material, design, and workmanship.
2. Provide products that have been in satisfactory commercial or industrial use for 2 years prior to Bid opening in similar applications under similar circumstances and of similar size. Provide products that have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the 2-year period.
3. Material and Equipment Manufacturing Date: Do not use products manufactured more than 3 years prior to date of delivery to Site.
4. **[A: Provide assembled fixture, complete with lamps, in accordance with California Code of Regulations Title 24 requirements.]**

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C. Preinstallation Meeting:

1. Occupancy Sensors: Arrange preinstallation meeting with manufacturer's factory authorized representative at the Project Site facility, to verify placement of sensors and installation criteria.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Metal Poles:

1. Provide manufacturer's standard protection for the finish during shipment and installation. At minimum, spirally wrap each pole shaft with protective paper secured with tape, and ship small parts in boxes.
2. Do not store poles on ground.
3. Support poles so they are at least 1 foot above ground level and growing vegetation.
4. Do not remove factory-applied pole wrappings until just before installing pole.
5. Ship poles with bolt circle template, base cover, handhold cover, and shaft cap or tenon.

PART 2 PRODUCTS

2.01 LUMINAIRES

A. Specific requirements relative to execution of the Work of this section are located on Drawings.

B. Provide luminaires and components tested, listed, and labeled by UL, or other approved testing agency.

C. Provide luminaires with Illumination Engineering Society of North America (IESNA) formatted photometric files, ".ies" format, certified by the luminaire manufacturer for use with lighting software.

D. Luminaire Labels:

1. External label per ANSI C136.15.
2. Internal label per ANSI C136.22.

E. Provide luminaires rated by the manufacturer to start and operate to their full lumen capacity for rated life of the luminaire at the minimum low and maximum high ambient temperatures as defined in the Contract Documents at their installation location.

F. Feed-through type, or separate junction box.

G. Wire Leads: Minimum 18 AWG.

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H. Component Access: Accessible and replaceable without removing luminaire from ceiling.

I. Soffit Installations (Interior or Exterior Damp Locations):

1. UL Labeled: SUITABLE FOR DAMP LOCATIONS.
2. Ballast: Removable, prewired.

J. Exterior Installations:

1. UL Labeled: SUITABLE FOR WET LOCATIONS.
2. Ballast: Removable, prewired.
3. When factory-installed photocells are provided, entire assembly shall have UL label.

K. Marine Environments:

1. UL Labeled: MARINE, OUTSIDE TYPE.
2. Housing: Copper-free, aluminum in accordance with UL 595.

L. Illuminated Exit Signs:

1. Body: As scheduled.
2. Face: **[A: Translucent.] [B: Stencil.]**
   a. Letters:
      1) 6-inch high by 3/4-inch stroke.
      2) Color: As scheduled.
3. Mounting: As indicated.
4. Directional Arrows: As indicated on Drawings.

M. Emergency Lighting Units:

1. Power Pack: Self-contained, 120/277-volt transformer, inverter/charger, sealed nickel cadmium battery, and indicator switch in accordance with UL 924.
2. Lighted, push-to-test indicator.
3. Capable of providing full illumination for 1-1/2 hours in emergency mode.
4. Capable of full recharge in 24 hours, automatically upon resumption of normal line voltage.
5. Capable of protecting against excess charging and discharging.
6. Emergency Self-Diagnostic System:
   a. Solid state device with LED display and audible alarm.
   b. Automatic and manual test unit.
   c. Test for malfunction of lamps, battery, and charger board.

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2.02 LAMPS

A. General:

1. Refer to Luminaire Schedule for specific lamp descriptions.
2. Lamps shall pass the Federal TCLP test in force at the time of manufacture.

2.03 LED SOURCE SYSTEMS

A. General:

1. Provide IESNA LM-80 test reports.
2. Provide Energy Star compliance for solid state luminaires.
3. Listed To: UL 8750 Standard for Safety for Light Emitting Diode (LED) Equipment for use in Lighting Products.
4. Provide RoHS compliant LED light source(s) and driver(s).
5. Warranty: 5 years minimum.

B. Electronic Module/Light Engine:

1. Mount all components to a single plate and factory prewired with quick-disconnect plugs.
2. Include a driver, thermal control device, thermal protector device, and surge protector device.
   a. Provide surge protector tested in accordance with IEEE/ANSI C62.41.2 to Category C Low.
3. Provide LEDs mounted to a metal-core circuit board and aluminum heat sink for optimal thermal management and long life.
4. Light Engine Rating per TM-21: 100,000 at 25 degrees C, L70.
5. Correlated Color Temperature (CCT): As indicated on the Luminaire Schedule. **[D: .]**
6. Color Rendering Index (CRI): Minimum of 80.

C. Drivers:

1. Expected life of 100,000 hours at 25 degrees C.
2. Provide drivers mounted in an all metal can.
3. Operating Voltage Range: 50/60-Hz input source of 120V with sustained variations of plus or minus 10 percent voltage with no damage to the driver.
4. Input Current Total Harmonic Distortion: Less than 20 percent up to 50 percent of full load rating.
5. Power Factor: Greater than 0.90 for primary application up to 50 percent of full load rating.
6. Sound rating: Class A.
7. Comply with NEMA 410 for inrush current limits.

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8. Dimming:
    a. Continuously dimmable from 10 percent to 100 percent.
    b. Provide driver compatible with dimming controls and dimming system used.

2.04 LIGHTING CONTROL

A. Time Switch, Electronic Programmable Type:

1. Provide digital electronic time switch with two channels.
2. Programming: Each channel shall be independently programmable and include:
    a. Two single-pole, double throw (Form C) dry contact, output rated for 30 amps at 120V ac for operation on LED driver loads.
    b. Provide channels with 4 ON/OFF set points in a 24-hour period for each day or the week.
    c. Skip-a-day weekly schedule.
    d. 365-day capability.
    e. Astronomic time functionality.
    f. Holiday override capability.
    g. Four seasonal schedule capabilities.
    h. User-programmable daylight savings time adjustment option.
    i. Automatic daylight savings changeover.
    j. Automatic leap year compensation.
    k. Manual Override: Until the next regularly-scheduled ON or OFF then resume normal operation.
3. Time Switch Minimum Features:
    a. Selectable am/pm or 24-hour format.
    b. 1-minute time resolution.
    c. Battery backup with rechargeable batteries and 1-week capacity.
    d. Individual manual ON/OFF override control for each channel.
4. Manufacturers:
    a. Tork.
    b. Intermatic.
    c. Paragon Electric Company.

B. Lighting Contactor:

1. Features:
    a. Electrically held contactor.
    b. Contacts Rating: 240 volts, 30 amperes, and 6 poles.
    c. Enclosure: NEMA 1 conforming to NEMA ICS 6.
    d. HAND-OFF-AUTOMATIC selector switch.

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C. Photo Sensors/Controls for Daylight Harvesting Control:

1. General.
    a. Operating Temperature: 32 degrees F to 120 degrees F.
    b. Environment: Indoor dry.
    c. Illumination Sensing Levels:
        1) 10 Foot-candles to 200 Foot-candles: General interior spaces.
    d. Output: Compatible with individual lighting load characteristics controlled.
2. Switching Control:
    a. Sensor shall sense relative lighting levels in interior spaces as daylight contribution varies throughout the day and shall convey changes to a control unit/power pack switching device. Switching device shall open and close load contacts based on field programmable set points.
    b. Power Pack:
        1) Dry contacts rated 20A at 120/277V ac.
        2) Adjustable Time Delay: 5 seconds to 300 seconds.
        3) Set point adjustment for both on and off operation.
3. Dimming Control:
    a. Sensor shall sense relative lighting levels in interior spaces as daylight contribution varies throughout the day and modulate electric luminaire lighting output to maintain a fixed lighting level in the space.
    b. Controller Unit:
        1) 120/277V ac input.
        2) 24V dc output to power the sensor.
    c. Sensor Output: 0V dc to 10V dc.
    d. Light level set point adjustment performed by separate hand held remote control device.

D. Wall Box Dimmers:

1. General:
    a. Modular gangable design.
    b. Solid-state circuitry.
    c. Voltage: 120 volt.
    d. ON/OFF switch integral to the unit. ON/OFF switch shall be independent of dimming level function.
    e. Single-pole or three-way as indicated on Drawings.
    f. Operator: Continuous adjustability throughout the dimming range.
    g. Integral suppression for audible frequency and EMI/RFI.
    h. Comply with UL 1472.

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2. Incandescent Dimmers:
    a. Wattage Ratings: Greater than circuit load requirements considering luminaire load and any derating required by manufacturer due to gangable installation.
3. Fluorescent Lamp Dimmers: Certified by manufacturer to operate on dimming ballasts provided with luminaires in this Project.
4. LED System Dimmers: Certified by manufacturer to operate on dimming drivers provided with luminaires in this Project.

E. Occupancy Sensors:

1. General:
    a. Capable of operating normally with any electronic ballast and PL lamp systems.
    b. Coverage of sensors shall remain constant after sensitivity control has been set. No automatic reduction shall occur in coverage due to cycling of air conditioner or heating fans.
    c. Provide sensors with readily accessible, user adjustable controls for time delay and sensitivity.
    d. Provide a bypass manual OVERRIDE ON key on each sensor to allow operation in the event of sensor failure. When bypass is utilized, lighting shall remain on constantly or control shall divert to a wall switch until sensor is replaced. Recess bypass control to prevent tampering.
    e. Provide an extra Form C (1-NO-1-NC) contact for each unit to interface with building system. Provide units mountable in standard electrical box.
    f. **[B: Provide units with an optional integral power pack.]**
2. Sensor Technology:
    a. Passive Infrared (PIR):
        1) Provide sensors that respond to human heat and movement to detect occupants in the coverage area.
        2) Temperature compensated pyroelectric sensor.
        3) High immunity to false triggering due to RFI and EMI noise.
        4) Provide passive infrared sensors with a multiple segmented lens, in a multiple-tier configuration, with grooves-in to eliminate dust and residue buildup.
        5) Detection Range (IR Range) on Axis: **[C: 1,200] [D:]** square feet.
    b. Ultrasonic:
        1) Provide sensors which respond to ultrasonic disturbances within as well as outside the line of sight to detect occupants in the coverage area.
        2) Use advanced signal processing technology to adjust the detection threshold dynamically to compensate for

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constantly changing levels of activity and airflow throughout the controlled space.

3) Detection Range (IR Range) on Axis: 500 square feet to 2,000 square feet.

c. Dual Technology:

1) Sensors use a combination of passive infrared and ultrasonic technologies to detect occupants in coverage area.

2) Provide technology mode selection to allow installer to configure the operation mode between dual technology, passive infrared only, or ultrasonic only functionality.

3) Detection Range (IR Range) on Axis: 2,000 square feet.

4) No audio dual technology units will be accepted.

3. Sensor Mounting:

a. Ceiling:

1) Directional Coverage: 360 degrees.

b. Wall:

1) Directional Coverage: 180 degrees.

c. Corner:

1) Coverage: 90 degrees.

d. Switch Box:

1) Directional Coverage: 180 degrees.

2) Coverage Area: At desk top level up to 300 square feet and gross motion up to 1,000 square feet.

3) Switch Types:

a) Single circuit switches shall control a single switched circuit.

b) Bi-level switches shall accommodate up to two switched circuits.

4) Loads:

a) Wall box switches shall include an integral power supply.

b) Switches shall accommodate loads from 0 watt to 800 watts at 120 volts; 0 watt to 1,200 watts at 277 volts.

2.05 POLES

A. General:

1. Design for wind load as specified in Section 01 61 00, Common Product Requirements, while supporting luminaires and other appurtenances. Use effective projected areas (EPA) of luminaires and appurtenances in calculations specific to the actual products proposed on each pole.
2. Poles 40 feet and Shorter: One-piece construction.
3. Pole Height: As indicated on Luminaire Schedule.

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4. Handhole:
    a. Provide oval-shaped handhole having a minimum clear opening of 2.5 inches by 5 inches.
    b. Secure cover with stainless steel captive screws.
    c. Metal Poles: Provide an internal grounding connection accessible from handhole near bottom of each pole.
5. Do not install scratched, stained, chipped, or dented poles.

B. Aluminum Poles:

1. Manufactured of corrosion-resistant aluminum alloys. Seamless extruded or spun seamless type with minimum 0.188-inch wall thickness.
2. Shape: As indicated on the Drawings.
3. Provide pole grounding connection designed to prevent electrolysis when used with copper ground wire.
4. Shaft Top: Fitted with cap.
5. Base:
    a. Anchor bolt mounted and machined to receive lower end of shaft.
    b. Welded joint between shaft and base.
    c. Base Cover: Cast aluminum alloy.
    d. Hardware, Except Anchor Bolts: either anodized aluminum alloy or stainless steel.
    e. Handhole.
6. Provide pole cast-in-place foundations with galvanized steel anchor bolts, threaded at the top end and bent 90 degrees at the bottom end.
7. Provide base covers to match pole and galvanized nuts and washers for anchor bolts.
8. Pole and Bracket Finish: **[G: Uniform satin] [H: Dark anodic bronze] [I: Dark bronze] [J: White] [K:]** finish to match fixture.

2.06 BRACKETS AND SUPPORTS

A. Features:

1. Not less than 1-1/4-inch aluminum secured to pole.
2. Select brackets for pole-mounted street lights to correctly position luminaire no lower than mounting height indicated.
3. Mount brackets not less than 24 feet above street.
4. Provide special mountings or brackets as indicated on Drawings fabricated of metal which will not promote galvanic reaction with luminaire head.

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2.07 POLE FOUNDATIONS

A. Anchor Bolts: Steel rod having a minimum yield strength of 50,000 psi; at minimum, galvanize the top 12 inches of the rod.

B. Concrete: As specified in Section 03 30 00, Cast-in-Place Concrete.

2.08 EMERGENCY BALLAST

A. In accordance with UL 924.

B. Nickel cadmium battery, charger, and electronic circuitry in metal case.

C. Solid state charging indicator monitoring light and double-pole test switch.

D. Capable of operating LED luminaire for a period of 90 minutes with output of 1,100 lumens to 1,200 lumens.

E. Manufacturers:

1. MagneTek Lighting Products.
2. Philips-Bodine.
3. Hubbell Lighting; Dual-Lite.
4. Lithonia.

2.09 IN-LINE FUSE HOLDER AND FUSE

A. Fuse Holder:

1. General: Waterproof, of corrosion-resistant material.
2. Rating: 600 volts.

B. Fuse:

1. General: Midget, dual element.
2. Rating: 5-amp, voltage as required by application.

C. Manufacturer: Methods Electronics Inc. Network, Buss Div.

2.10 EQUIPMENT IDENTIFICATION

A. Manufacturer’s Nameplate: Provide each item of equipment with a nameplate bearing manufacturer’s name, address, model number, and serial number securely affixed in a conspicuous place; nameplate of distributing agent will not be acceptable.

B. Provide clear markings located to be readily visible to service personnel.

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2.11 FACTORY FINISH

A. Provide electrical equipment with factory-applied painting systems that, at minimum, meet the requirements of NEMA 250 corrosion-resistance test.

PART 3 EXECUTION

3.01 LUMINAIRES

A. General:

1. Install in accordance with manufacturer's recommendations.
2. Provide proper hangers, pendants, and canopies as necessary for complete installation.
3. Provide additional ceiling bracing, hanger supports, and other structural reinforcements to building and to concrete pole bases required to safely mount.
4. Install plumb and level.
5. Install each luminaire outlet box with galvanized stud.

B. Mounting:

1. General:
   a. Coordinate mounting, fastening, and environmental conditions with Section 26 05 02, Basic Electrical Requirements.
   b. Refer to Fastener Schedule in Section 05 50 00, Metal Fabrications.
2. Wall Mounted: Measure mounting heights from center of mounting plate to finished floor or finished grade, whichever is applicable.
3. Pendant Mounted:
   a. Provide swivel type hangers and canopies to match luminaires, unless otherwise noted.
   b. Space single-stem hangers on continuous-row fluorescent luminaires nominally 48 inches apart.
   c. Provide twin-stem hangers on single luminaires.
   d. Measure mounting heights from bottom of luminaire to finished floor or finished grade, whichever is applicable.
4. Pole Mounted:
   a. Provide cast-in-place or precast concrete base.
   b. Provide branch circuit in-line fuses in pole base handhole.

C. Swinging Type: Provide, at each support, safety cable capable of supporting four times vertical load from structure to luminaire.

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D. Finished Areas:

1. Install symmetrically with tile pattern.
2. Locate with centerlines either on centerline of tile or on joint between adjacent tile runs.
3. Install recessed luminaires tight to finished surface such that no spill light will show between ceilings and sealing rings.
4. Combustible Low Density Cellulose Fiberboard: Provide spacers and mount luminaires 1-1/2 inches from ceiling surface, or use fixtures suitable for mounting on low density ceilings.
5. Junction Boxes:
    a. Flush and Recessed Luminaires: Locate minimum 1-foot from luminaire.
    b. In concealed locations, install junction boxes to be accessible by removing luminaire.
6. Wiring and Conduit:
    a. Provide wiring of temperature rating required by luminaire.
    b. Provide flexible steel conduit.
7. Provide plaster frames when required by ceiling construction.
8. Independent Supports:
    a. Provide each recessed fluorescent luminaire with two safety chains or two No. 12 soft-annealed galvanized steel wires of length needed to secure luminaire to building structure independent of ceiling structure.
    b. Select chain or wire with tensile strength and method of fastening to structure adequate to support luminaire weight.
    c. Fasten chain or wire to each end of luminaire.

E. Unfinished Areas: Locate luminaires to avoid conflict with other building systems or blockage of luminaire light output.

1. Fixture Suspension: Provide 1/4-inch threaded steel hanger rods. Scissor type hangers not permitted.
2. Attachment to Steel Beams: Provide flanged beam clips and straight or angled hangers.

F. Building Exterior: Flush-mounted back box and concealed conduit, unless otherwise indicated.

3.02 LAMPS

A. Provide in each fixture, number and type for which fixture is designed, unless otherwise noted.

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3.03 BALLASTS

A. Install in accordance with manufacturer's recommendations.

B. Utilize all ballast mounting holes to fasten securely within luminaire.

C. Replace noisy or defective ballasts.

3.04 LIGHTING CONTROL

A. Outdoor Luminaires: Provide electronic programmable time switch to control lighting contactor.

1. Turn lights on at dusk and turn off at 7:00 pm.
2. Turn lights on at 5:30 am and off at sunrise.

B. Dimming Systems:

1. Install in accordance with manufacturer's recommendations.
2. Do not connect ballasts or equipment to dimming system unless acceptable to dimming system manufacturer.

C. Occupancy Sensors: Locate and aim sensors in correct location required for complete and proper volumetric coverage within range of coverage(s) of controlled areas per manufacturer's recommendations. Provide 90 percent to 100 percent room coverage to accommodate all occupancy habits of single or multiple occupants at any location within room(s). Locations and quantities of sensors shown on Drawings are diagrammatic and only indicate which rooms are to be provided with sensors. Provide additional sensors if required to properly and completely cover respective room.

3.05 EMERGENCY BALLAST

A. Install battery, charger, and electronic circuitry metal case inside fluorescent fixture housing.

B. Install monitoring light and double-pole switch adjacent to light fixture.

C. Wire in accordance with manufacturer's wiring diagrams.

3.06 EMERGENCY LIGHTING UNIT

A. Install in accordance with manufacturer's recommendations.

B. Provide permanent circuit connections with conduit and wire.

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C. Connect to branch circuit feeding normal lighting in area ahead of all local switches.

D. Provide separate circuit wiring to luminaire.

3.07 POLES

A. Electrical Installations: Conform to IEEE C2 and requirements specified herein.

B. Pole Setting:

1. Depth: As indicated on Drawings or footing detail.
2. Install poles in straight runs in a straight line.

C. Aluminum Poles: Install according to pole manufacturer's instructions.

1. Provide cast-in-place or precast concrete base.
2. Provide 5A branch circuit in-line fuses in pole base handhole.

D. Grounding: Ground noncurrent-carrying parts of equipment including metal poles, luminaires, mounting arms, brackets, and metallic enclosures as specified in Section 26 05 26, Grounding. Where copper grounding conductor is connected to a metal other than copper, provide specially treated or lined connectors suitable for this purpose.

3.08 FIELD FINISHES

A. Paint electrical equipment as required to match finish of adjacent surfaces or to meet the indicated or specified safety criteria. Paint as specified in Section 09 90 00, Painting and Coating.

3.09 FIELD QUALITY CONTROL

A. Upon completion of installation, verify equipment is properly installed, connected, and adjusted. Conduct an operating test to show equipment operates in accordance with the requirements of this section.

B. Coordinate lighting and controls installation and testing with commissioning as specified in Section 01 91 14, Equipment Testing and Facility Startup.

3.10 MANUFACTURER’S SERVICES

A. Occupancy Sensors and Daylight Harvesting Controls:

1. Furnish manufacturer’s representative at Job Site **[B: in accordance with Section 01 43 33, Manufacturers’ Field Services,]** to inspect installation, test unit, and put into service.

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2. Provide, at the job site, training necessary to familiarize Owner's personnel with operation, use, adjustment, and problem solving diagnosis of occupancy sensing devices and systems.

3.11 CLEANING

A. Remove labels and markings, except UL listing mark.

B. Wipe luminaires inside and out to remove construction dust.

C. Clean luminaire plastic lenses with antistatic cleaners only.

D. Touch up painted surfaces of luminaires and poles with matching paint ordered from manufacturer.

E. Replace defective lamps at time of Substantial Completion.

END OF SECTION

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SECTION 27 13 13
ETHERNET NETWORK SYSTEM

PART 1 GENERAL

1.01 SUMMARY

A. This section covers the furnishing of all network hardware and software for the Control System. Principal components of the Ethernet Network System shall be as described below.

B. The Contractor shall furnish all necessary equipment, interconnecting cables, and accessories for proper network operation and to meet the functional requirements specified herein.

C. Equipment and services provided under this section shall be subject to the general requirements specified in the Control System section. Supplementing this section, network data, special requirements, and options may be indicated on the Drawings.

1.02 GENERAL

A. The Contractor shall install all equipment in accordance with the manufacturer's instructions. Equipment and materials used shall be subject to review and shall comply with the following requirements.

1. If requirements in this specification differ from those in Section XX, the requirements specified herein shall take precedence.
2. Supplementing this section, the Drawings indicate locations and arrangement of hardware and enclosures, provide mounting details, and may show other information regarding the connection and interaction with other equipment.
3. Unless otherwise specified, electric power supply to the network equipment shall be 24V dc or 120V ac as required by the equipment, and UPS backed up. Any required power supplies, special cable, special grounding, and isolation devices shall be furnished for proper performance of the equipment.
4. To the extent possible, components used for similar types of functions and services shall be the same brand and model line. Similar components of different network hardware shall be the products of the same manufacturer to facilitate maintenance and stocking of repair parts. Whenever possible, identical units shall be furnished.

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1.03 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Telecommunications Industry Association/Electronic Industries Association (TIA/EIA):
    a. 568-B/C (Series), Commercial Building Telecommunications Cabling Standards.
    b. 569 (Series), Commercial Building Standard for Telecommunications Pathways and Spaces.
    c. 526 (Series), Standard Test Procedures for Fiber Optic Systems.
    d. 604 (Series), Fiber Optic Connector Intermateability Standard (FOCIS).
2. International Electrotechnical Commission (IEC):
    a. 11801 (Series), Cabling for Customer Premises.
    b. 24702, Information technology - Generic cabling- Industrial premises.
    c. 60068 (Series), Environmental Testing.
    d. 60529, Degrees of protection provided by enclosures (IP Code).
    e. 60603-7, Connectors for electronic equipment - Detail specification for 8-way, unshielded, free and fixed connectors.
    f. 61000 (Series), Electromagnetic compatibility (EMC).
    g. 61076 (Series), Connectors for electronic equipment - Product requirements.
    h. 61131-2, Programmable controllers - Equipment requirements and tests.
    i. 61326 (Series), Electrical equipment for measurement, control and laboratory use - EMC requirements.
3. American National Standards Institute/International Society of Automation (ANSI/ISA):
    a. 99, Security for Industrial Automation and Control Systems.
4. Institute of Electrical and Electronic Engineers, Inc. (IEEE):
    a. 802 (Series), Standards for Local and Metropolitan Area Networks.
    b. 1588, Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems
5. Internet Engineering Task Force (IETF) RFC documents (various).

1.04 SUBMITTALS

A. Submittals shall be made in accordance with the requirements of this section. Each submittal shall be complete, with all required information provided together at one time, and submitted in a sequence that allows the Owner to have all of the information necessary for checking and approving a particular document at the time of the submittal. The Contractor shall be responsible for

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planning and making all submittals as necessary to avoid delays or conflicts in the work.

B. The complete Ethernet Network System design shall be submitted together, allowing a complete review of the design and components. The Ethernet Network System Design submittal shall include:

1. Product data for all networking hardware, including:
    a. Manufacturer's operation and installation instructions.
    b. Data sheets, technical product brochures or bulletins.
2. Complete installation, operation, calibration, and testing manuals.
3. Complete set of drawings, including but not limited to:
    a. System block diagram showing relationship and connections between devices, including manufacturer and model information, and address settings.
    b. Detailed physical network topology diagram detailing all hardware and the interconnections, including physical media type and cabling distances.
    c. Network riser diagram.
    d. Network port diagram that shows physical location of all ports within the facility and identifies their patch panel and switch port.
    e. Construction drawings for all equipment cabinets, including dimensions, identification of all components, preparation and finish data, nameplates.
    f. Electrical connection diagrams including complete grounding requirements.
4. A detailed description of the configuration requirements for all components that are to be configured by the Contractor.
5. Complete and detailed bills of materials for the cabling infrastructure and network infrastructure broken up by each cabinet.
6. A report on the projected bandwidth usage of the Ethernet network and each of the individual nodes on the network to ensure there are no bottlenecks and that there is the required percentage of bandwidth available for expansion.
7. Network Testing Plan, Procedures, and Test Reports in accordance with Part 3 of this section, that shall include:
    a. Narrative describing the test procedures followed.
    b. Block diagram of test set up.
    c. Manufacturer's information on test equipment used.
    d. Detailed test results.
    e. A narrative summarizing the results of the testing and identifying any further action required.

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1.05 FUNCTIONAL REQUIREMENTS

A. Network Standard Compliance:

1. The network system shall be based on existing IEEE 802.3 Ethernet standards. There shall be no modifications of Ethernet protocol that create incompatibility with commercial off-the-shelf Ethernet products.
2. The network system shall use standard unmodified TCP, UDP and IP protocols for Ethernet frame encapsulation and transport across the network, as specified in the IETF RFC documents.
3. The network system shall be able to integrate into other parts of the manufacturing network and to communicate with the enterprise network equipment using open-standard non-proprietary protocols. The network components shall be interoperable with standard network equipment, such as switches, routers, firewalls.

B. Industrial Protocol Requirements: The network system shall utilize a common industrial application layer protocol, using a single media-independent network technology, enabling interoperability across a broad range of vendors and devices. This protocol shall be managed by a vendor neutral organization that maintains conformance testing to ensure vendor interoperability and specification compliance.

C. Network Design Requirements:

1. The network system shall be designed to meet the following requirements:
   a. The network shall be able to meet real-time communication requirements of the industrial control equipment.
   b. The network shall have resources available to support the required number of network nodes and amount of traffic they generate, with additional capacity for future expansion.
   c. The network shall provide high availability for all critical components by using redundant network hardware, power supplies and power sources, cabling infrastructure and network data paths.
   d. The network shall be compliant with the ANSI/ISA-99 standards for industrial automation and control system security.

PART 2 PRODUCTS

2.01 NETWORK CABLING

A. Ethernet Media Support:

1. The following Ethernet physical media standards shall be supported in the network:

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a. 100Base-TX copper.
b. 1000Base-TX copper.
c. 100Base-FX fiber (multi-mode and single mode).
d. 1000Base-SX fiber (multi-mode).
e. 1000Base-LX fiber (single mode).

B. Environmental Considerations: Environmental factors of each area of the IACS network shall be assessed using M.I.C.E. analysis as recommended by the ANSI/TIA-568-C.0 standard. Cabling components and forms of mitigation shall be selected based on this assessment.

C. Commercial Copper Media Cables: Two-pair and four-pair twisted pair cables (shielded or unshielded) shall meet the transmission performance requirements of ANSI/TIA/EIA-568-B standards.

D. Commercial RJ-45 Connectors: Commercial non-sealed RJ-45 connectors shall conform to ANSI/TIA/EIA-568-B.2 standards and meet the mechanical and electrical requirements of IEC 60603-7 series standards.

E. Commercial Fiber Media Cables: The following fiber optic cable shall be supported and meet the requirements of ANSI/TIA/EIA 568-C.3 standards:

1. Multi-mode 50/125µm.
2. Multi-mode 62.5/125µm.
3. Single mode 9/125µm.

F. Commercial Fiber Connectors: Commercial non-sealed fiber connectors shall be limited to the LC, SC, SCRJ, and ST variants. Fiber connectors shall conform to ANSI/TIA/EIA-568-C.3 and TIA/EIA-604 FOCIS standards. The LC connector variants shall be used for all new installations. LC transceivers shall have duplex jacks with center spacing compatible with the FOCIS standard.

G. Industrial Cabling Components: Copper and fiber industrial cabling components shall support the minimum environmental recommendations of IEC 60068-2 standards, and EMI requirements for IEC light industrial (IEC 61000-4, 61000-6, 61131-2, 61326-1).

H. Industrial Copper Media Cables:

1. The following industrial Ethernet cabling shall be available for installation in harsh environments:
   a. Cat5e unshielded twisted pair cable (UTP), four- and eight-conductor styles.
   b. Shielded twisted pair cable (STP), four- and eight-conductor styles.

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c. 600V STP cable, four- and eight-conductor styles, for use in a cable tray shared with high voltage power cables.

I. Cabling shall be designed to IEC 24702 standards and be suitable for high noise M3I3C3E3 (industrial) environments. Industrial cabling components should meet the minimum environmental recommendations of IEC 60068-2 series standards.

J. Industrial Copper Connectors:

1. The industrial non-sealed RJ-45 connectors shall meet the following requirements:
   a. Cat5e tested connector.
   b. Designed to withstand IP20 industrial applications.
   c. Suitable for M1I1C2E2 (light industrial) environments.
   d. Meet IEC 60603-7 specifications.
2. The industrial sealed RJ-45 connectors shall meet the following requirements:
   a. Cat5e tested connector.
   b. Designed to withstand IP67 industrial applications.
   c. Suitable for M3I3C3E3 (industrial) environments.
   d. Meet IEC 61076-3-106 specifications.
3. The industrial sealed M12 “D”-coded connectors shall meet the following requirements:
   a. Cat5e tested connector.
   b. Designed to withstand IP67 industrial applications.
   c. Suitable for M3I3C3E3 (industrial) environments.
   d. Meet IEC 61076-2-101 specifications.

K. Industrial Fiber Media Cables: Ruggedized IP-rated fiber cables shall be used for indoor and outdoor industrial applications.

L. Industrial Fiber Connectors and SFP Modules: Sealed industrial LC, M12, and SCRJ fiber connectors shall meet the requirements of the corresponding ANSI/TIA/EIA documents and be fully compatible with off-the-shelf fiber optic plugs and jacks.

M. Network Equipment Enclosures:

1. Network equipment enclosures shall be used to house networking devices and patch panels in harsh environments, unless the network hardware is designed for mounting in such environment.
2. Network equipment enclosures shall provide a wire duct for communication cables and fiber optic cables between the communication devices in control panel and communication raceways. Plastic wire duct design shall take into account minimum bend radius of communications cable.

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3. Patch Panels: Cabling systems shall utilize patch panels, surface mount box, or other enclosure, which allows the cable to be permanently terminated and tested. Direct cabling to switches shall be avoided. Connections between switches and patch panels will be made with patch cables not exceeding 3 meters in length and shall conform to ISO/IEC 11801 standards.

2.02 INDUSTRIAL ETHERNET SWITCHES

A. Environmental and Power Specifications:

1. Industrial Ethernet switches shall meet the following environmental and power specifications:
   a. IEC 60529 IP20 or IP30 environmental rating.
   b. Industrial DIN-rail enclosure.
   c. Passive cooling with no moving parts.
   d. Operating temperature 0 degrees C to plus 60 degrees C.
   e. Ambient relative humidity 5 percent to 95 percent (non-condensing).
   f. Redundant power source 12 to 48V dc.
   g. Two front panel connectors for DC power and alarm signals.
   h. Internal temperature sensors.
   i. Two independent alarm relays.
2. Extended temperature, vibration, shock and surge, and noise immunity ratings shall comply with specifications for industrial environments.

B. Certifications:

1. UL Listed Industrial Control Equipment for Class I, Division 2 Group A, B, C, D Hazardous Locations, certified for US and Canada.
2. European Union 2004/108/EC EMC Directive, compliant with EN 61326-1 Meas./Control/Lab., Industrial Requirements; EN 61000-6-2 Industrial Immunity; EN 61000-6-4 Industrial Emissions; EN 61131-2 Programmable Controllers (Clause 8, Zone A and B).

C. Ethernet Media Support:

1. Industrial Ethernet switches shall support one or several of the following media types for end device connectivity:
   a. 100Base-TX copper with RJ-45 ports.
   b. 100Base-FX multi-mode fiber with small form-factor pluggable (SFP) slots or built-in ports.
   c. 1000Base-TX copper with RJ-45 ports.
   d. Industrial Ethernet switches shall support one or several of the following media types for connectivity to other industrial switches and distribution layer devices:
   e. 100Base-TX copper with RJ-45 ports.

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f. 100Base-FX multi-mode and single mode fiber with SFP slots.
g. 1000Base-TX copper with RJ-45 ports.
h. 1000Base-SX multi-mode fiber with SFP slots.
i. 1000Base-LX single mode fiber with SFP slots.

D. Ethernet Port Configurations:

1. Industrial Ethernet switches shall have one of the following numbers of ports:
   a. 6 ports, fixed configuration.
   b. 6 ports expandable up to 24 ports with extension modules.
   c. 10 ports, fixed configuration.
   d. 10 ports expandable up to 24 ports with extension modules.
   e. 20 ports, fixed configuration.
2. The switches with Gigabit speed capabilities shall have one of the following:
   a. Two copper ports (RJ-45).
   b. Two SFP slots.
   c. Two dual-purpose ports (RJ-45 or SFP).

E. Switching Hardware Specifications:

1. Industrial Ethernet switches shall meet the following switching hardware characteristics:
   a. Line rate/non-blocking ports.
   b. Wire-speed switching with 16 Gbps switching fabric.
   c. Forwarding Rate Based on 64-Byte Packets: 6.5 Mpps.
   d. 128 or 256 MB DRAM, 64 MB on-board flash memory.
   e. Configurable up to 8000 MAC addresses and 255 IGMP multicast groups (Layer 2 switch).
   f. Configurable up to 2000 MAC addresses and 1000 IGMP groups (Layer 3 switch).

F. Hardware Alarms:

1. Industrial Ethernet switches shall be able to trigger an alarm when the following fault conditions occur:
   a. Power supply fault.
   b. Low and high temperature.
   c. FCS bit error rate exceeded.
   d. Link fault (loss of signal).
   e. Port not forwarding.
   f. Port not operating (startup self-test fault).
2. The alarms shall be configurable in software and be able to use these methods for notifications:

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a. System message to a logging facility (syslog).
b. Simple Network Management Protocol (SNMP) traps to a server.
c. Use of alarm relays to trigger an external alarm device.

G. LED Indicators:

1. Industrial Ethernet switches shall have LED indicators displaying hardware and network link status:
   a. Module status indicator with the following states:
      1) Switch is operating properly.
      2) A recoverable minor fault has occurred.
      3) A non-recoverable major fault has occurred.
      4) The switch is performing a power-on self-test (POST).
   b. Network status indicator with the following states:
      1) The device has at least one established connection to a control system.
      2) Control system connection has timed out.
      3) Duplicate IP address.
      4) The switch is performing a POST.
   c. Setup status indicator with the following states:
      1) Switch is configured as a managed switch.
      2) Switch is in initial setup.
      3) Switch is in recovery state or initial setup is incomplete.
      4) Switch failed to start initial setup or recovery.
      5) Power status indicator.
   d. Port status indicators with the following states:
      1) No link.
      2) Link present.
      3) Port is sending or receiving data.
      4) Link fault.
      5) Port is disabled due to an address violation, Ethernet loop detection, or manual configuration.

H. Removable Storage: Industrial Ethernet switches shall have a hot-swappable storage device (CompactFlash or SD flash memory card). The switch shall continue to operate while the storage device is being replaced. All configuration and firmware files shall be saved on the removable storage device for quick field replacement of the failed switch.

I. Control System Integration:

1. Industrial Ethernet switches shall support a common application layer protocol used for the control system for configuration and monitoring purposes. The switch shall have the ability to be added as an I/O device to a programmable logic controller (PLC) and provide an application protocol interface for read-only and read-write access to switch

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parameters. This interface shall provide the following information and configuration capabilities:

a. Port status and enable/disable configuration.
b. Port error and media counters.
c. Port bandwidth utilization.
d. Port security configuration and violations.
e. Switch alarm status.
f. Multicast group information.
g. Port enable/disable.
h. Power supply and temperature status.
i. Firmware and hardware identity information.
j. Control system connection information.
k. IP address information and configuration.
l. Switch configuration save and restore.

J. Diagnostic and Monitoring:

1. Industrial Ethernet switches shall support the following methods of diagnostic and monitoring:
   a. Web interface (HTTP).
   b. System message logging (syslog).
   c. SNMP protocol Version 2c and 3.
   d. Port mirroring.
   e. Application protocol interface to a control system.

K. Configuration:

1. Industrial Ethernet switches shall have the following configuration options:
   a. Initial setup procedure with a web browser that configured basic parameters for typical industrial applications.
   b. Web browser configuration.
   c. Built-in global or interface-level macros (command templates) that allow easily set up the switch in a configuration optimized for the specific application.
   d. Application protocol interface using the same software and tools as for a control system.
   e. SNMP configuration.
   f. Command line configuration (CLI) via serial console line, Telnet, or SSH protocols.
2. CLI configuration shall NOT be required for a switch to operate in a typical industrial network, and shall be reserved only for advanced configuration.
3. Preconfigured templates (macros) shall be available to enable global and interface level features for a typical industrial automation applications.

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L. Network Standard Compliance:

1. Industrial Ethernet switches shall implement existing IEEE 802.3 Ethernet standards with no modifications of Ethernet protocol that create incompatibility with commercial off-the-shelf Ethernet products.
2. Industrial Ethernet switches shall be able to integrate into other parts of the manufacturing network and to communicate with the enterprise network equipment using open-standard non-proprietary protocols.

M. Network Protocol Support:

1. Industrial Ethernet switches shall be available with standard and advanced software set.
2. Industrial Ethernet switches with standard software set shall include the following networking functionality based on open standards protocols:
    a. VLAN and Trunking Support: IEEE 802.1q.
    b. Rapid Spanning Tree Protocol (RSTP): IEEE 802.1w.
    c. Multiple Spanning Tree Protocol (MSTP): IEEE 802.1q-2005.
    d. Multicast Traffic Management with IGMPv3 Snooping, Filtering and Querier: RFC 4541.
3. Industrial Ethernet switches with advanced software set shall include additional functionality:
    a. Link aggregation (Etherchannels) LACP: IEEE 802.3ad.
    b. DHCP Server and DHCP Persistence (Port-Based Allocation): RFC 2131.
    c. Quality of Service (QoS).

N. Prioritization (QoS) Support:

1. Industrial Ethernet switches with advanced software set shall be able to prioritize automation control traffic using Quality of Service (QoS). The following standards shall be supported:
    a. Layer 3 QoS based on DSCP classification (DiffServ).
    b. Layer 2 QoS: IEEE 802.1p.
2. Switches shall have at least two ingress and four egress packet queues and shall be able to configure priority queue for handling critical traffic. Switches shall have built-in macro commands for simplified configuration of QoS mapping, classification, and scheduling. The following classes of traffic shall be prioritized:
    a. Time synchronization.
    b. Motion control.
    c. Safety I/O and messaging.
    d. Standard I/O and messaging.

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O. Time Synchronization: Industrial Ethernet switches with time synchronization capabilities shall support IEEE 1588 Precision Time Protocol (PTP). Switches shall support end-to-end transparent and boundary PTP modes.

P. Switch Ring Topology: Industrial Ethernet switches shall include a loop-prevention network protocol with the ability to support large number of switches in a ring topology. The protocol convergence time shall meet the requirements of typical industrial applications.

Q. Security Features:

1. Industrial Ethernet switches shall include the following security features:
    a. Username and password for remote and local (console) access.
    b. Password for the read-write access to parameters from a control system.
    c. Authentication Protocol Support: AAA, RADIUS.
    d. Secure Management Protocols: SSHv2, SNMPv3, HTTPS.
    e. Industrial Ethernet switches with advanced software set shall support the following:
    f. Port-based authentication and VLAN assignment: IEEE 802.1x.
    g. MAC ID port security.
    h. DHCP snooping and IP source guard.
    i. Dynamic ARP inspection and rate limiting.
    j. Port-based IP and MAC access lists (ACL).
    k. Port-based broadcast, multicast, and unicast storm control.

R. Layer 3 Routing:

1. Industrial Ethernet switches with Layer 3 routing capabilities shall include the following functionality:
    a. Inter-VLAN IP routing.
    b. Static routing and dynamic routing protocols.
    c. IP multicast routing with PIM protocol.
    d. First hop redundancy protocol support.

2.03 EMBEDDED SWITCH DEVICES

A. General Requirements:

1. Ethernet devices with embedded switch technology shall have two Ethernet ports to connect to a linear or device-level ring topology (DLR). Such devices shall meet the following requirements:
    a. Support of a DLR topology with a resiliency to a single point of failure.
    b. Support of fast recovery time after a single fault that is sufficient for high demand control applications.

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c. Ability to operate with non-DLR switches and devices in the common network infrastructure.
d. QoS support consistent with the rest of the control network, with a high priority queue for DLR frames and strict priority scheduling for the critical automation traffic.
e. Broadcast rate limiting to host CPU.
f. Incoming unicast and multicast traffic filtering to host CPU.
g. IEEE 1588 support for time synchronization.

2. Embedded switch devices shall be able to operate using standard IEEE 802.3 technology. There shall be no modifications of Ethernet protocol that create incompatibility with commercial off-the-shelf Ethernet products.

B. Supervisor Node Requirements:

1. In the DLR network, ring supervisor shall have the following features:
a. Verification of the integrity of the ring.
b. Reconfiguration of the ring to recover from a single fault.
c. Ability to provide diagnostic information about ring status and fault location via HTTP or using a control system application protocol.

C. Ethernet Tap Requirements:

1. Ethernet taps shall be used to connect devices that do not support embedded switch technology, and shall meet the following requirements:
a. Two 100 Mbps copper or fiber ports connect to a linear or a DLR network.
b. One 100 Mbps copper port for end device connectivity, or to provide port mirroring capabilities.
c. IGMP snooping and IGMP querier functions.
d. Ring supervisor capability.
e. Ring diagnostics via HTTP and control system application protocol interface.

2.04 ETHERNET COMMUNICATION MODULES

A. General Requirements:

1. Ethernet communication modules provide network interface for control system components such as programmable controllers and I/O devices. Ethernet communication modules shall be able to operate using standard IEEE 802.3 technology. There shall be no modifications of Ethernet protocol that create incompatibility with commercial off-the-shelf Ethernet products.

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2. Ethernet communication modules shall have a functional TCP/IP and UDP protocol suite and transport mechanism, as covered in RFC 1122, 1123, 1127 and the subsequent documents. Any new features or protocols shall be implemented in accordance to the appropriate RFC documents.

B. LED Indicators:

1. Ethernet communication modules shall have LED indicators displaying module, network port and control system connection status:
    a. Module status indicator with the following states:
        1) Module is operating properly.
        2) A recoverable minor fault has occurred.
        3) A non-recoverable major fault has occurred.
        4) Module is performing a power-on self-test (POST).
    b. Network status indicator with the following states:
        1) Module has at least one established control system connection.
        2) Control system connection has timed out.
        3) Duplicate IP address.
        4) Module is performing a POST.
    c. Port status indicator with the following states:
        1) The module is not ready to communicate on the port.
        2) The module is ready to communicate.
        3) The module is communicating over the network.

C. Ethernet Interfaces and Media Support:

1. Ethernet communication modules shall support either one of the following Ethernet media standards:
    a. 100Base-TX copper with RJ-45 connector.
    b. 1000Base-TX copper with RJ-45 connector.
    c. 100Base-TX copper with M12 D-coded connector.
    d. 1000Base-LX multimode fiber with LC connector.

D. Diagnostic and Monitoring:

1. Ethernet communication modules shall have the following methods of diagnostic and monitoring:
    a. Web interface (HTTP).
    b. Application protocol interface to a control system.
    c. LED indicators and diagnostic displays.
2. The following information shall be available for diagnostic and monitoring:
    a. System resource utilization.
    b. Current network settings.

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c. Ethernet statistics.
d. I/O connection information.
e. Diagnostic messages.

E. Configuration Methods:

1. Ethernet communication modules shall at least support the following configuration methods:
   a. Full configuration using Ethernet port and control system application protocol.
   b. Automatic IP address configuration using Ethernet port and BOOTP/DHCP protocol.
2. The following methods may also be supported:
   a. Manual IP address configuration with rotary switches on the module.
   b. Full configuration using USB port and control system application protocol.
   c. HTTP interface configuration.
3. If configuration via a web browser interface is implemented, it shall be password protected.

F. Network Configuration:

1. Ethernet communication modules shall satisfy the following network configuration requirements:
   a. Static or BOOTP/DHCP IP address configuration shall be supported.
   b. Any valid IP address and subnet mask configuration shall be supported. There shall be no limitation on mask length or IP subnet range.
   c. The module shall have default gateway configuration option.
   d. The module shall have primary and secondary DNS server, and domain name configuration options.
   e. Auto-negotiate or manual speed and duplex port settings shall be supported. Half or full duplex and 10 Mbps or 100 Mbps operation shall be supported.

G. Network Protocol Support:

1. Ethernet communication modules shall at a minimum support the following protocols and standards:
   a. Internet Protocol (IP Version 4): RFC 791.
   b. User Datagram Protocol (UDP): RFC 768.
   c. Transmission Control Protocol (TCP): RFC 793.
   d. Address Resolution Protocol (ARP): RFC 826.
   e. Internet Control Messaging Protocol (ICMP): RFC 792.

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f. Internet Group Management Protocol (IGMP): RFC 1112, 2236.
g. IEEE 802.3 (Ethernet): RFC 894.
h. HTTP protocol for diagnostic and configuration purposes.

H. Address Conflict Detection: Ethernet communication modules shall implement IP address conflict detection (ACD) mechanism and display the conflict mode via LED indicators and diagnostic messages.

PART 3 EXECUTION

3.01 NETWORK INSTALLATION

A. The Contractor shall follow these requirements when installing network equipment and cabling:

1. All racks shall be level and plumb.
2. All cable bundles within the network rack/enclosure shall be secured and tied with Velcro wrap.
3. All cables and equipment shall be installed in strict conformance with the manufacturer's recommendations:
   a. Cables shall be installed avoiding sharp bends.
   b. Install cable using lubricant designed for cable pulling.
   c. Cable ties or other cable supports shall be installed without crimping the LAN cables.
   d. Install LAN cables without splices.
   e. Installed bend radii shall not exceed four times the cable diameter.
   f. Terminate all pairs at the jack and the patch panel.
   g. Install cables a minimum of 40 inches away from electrical motors and transformers.
   h. Install cables a minimum of 12 inches away from fluorescent lighting.
   i. Individual pairs will be untwisted less than 1/2 inch at termination points.
4. All cables and terminations shall be labeled with cable designations.
5. Each data port shall be individually labeled with its patch panel/switch port ID.
6. At the completion of the wiring installation, provide the following documentation:
   a. A plan-view of the premise(s) showing the jack numbering scheme.
   b. A printed certification report for the entire wiring installation showing compliance with all ANSI/EIA/TIA specifications for data cable.
7. Each device with a unique IP address shall be individually labeled with its IP address.

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3.02 NETWORK CONFIGURATION

A. The Contractor shall provide a configuration report to the Owner detailing all the configuration parameters for all Contractor-configured devices that connect to the network, including but not limited to the following:

1. IP address, subnet mask, default gateway assignments.
2. DNS hostname, domain, and server assignments.
3. Speed and duplex configuration for each network interface.
4. Access VLAN configuration or trunking mode for each switch port.
5. User access passwords for network device management.
6. Switch configuration files in text (CLI) format.

3.03 NETWORK TESTING

A. Specifications and Guidelines:

1. All tests, verifications, checks, and recommendations shall be in conformance with the ANSI/TIA or ISO/IEC specifications. ANSI/TIA or ISO/IEC specifications define electrical and mechanical parameters that are the basis for all tests and test equipment usage defined in this section.
2. All tests, verifications, checks, and recommendations shall be in conformance with all applicable vendor specifications and guidelines. Manufacturers' specifications and guidelines may define additional electrical and mechanical parameters beyond ANSI/TIA or ISO/IEC specifications, and must be included in the basis for all tests and test equipment usage defined in this section.

B. Ethernet Network Testing Equipment: The Contractor shall utilize any required test equipment, equipment management tools, and additional tools as needed to validate the network installation. All test equipment shall bear current calibration certification from a certified calibration laboratory, as appropriate.

C. Testing of Installed Twisted-Pair Cabling Links:

1. The installed twisted-pair copper cabling links shall be tested to meet the requirements of the ANSI/TIA/EIA 568-B standards and to the maximum rating for the grade of the installed cable. The following parameters shall be tested for each cable pair and/or for both ends (where applicable):
   a. Wire Map: Presence of opens, shorts, crossed, reversed, transposed, and split pairs.
   b. DC Loop Resistance.
   c. Length.
   d. Propagation Delay.

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e. Delay Skew.
f. Insertion Loss.
g. Return Loss measured from both ends.
h. Near-End Cross Talk (NEXT).
i. Power Sum Near-End Cross Talk (PSNEXT).
j. Attenuation to Crosstalk Ratio Near-End (ACR-N).
k. Power Sum Attenuation to Crosstalk Ratio Near-End (PSACR-N).
l. Attenuation to Crosstalk Ratio Far-End (ACR-F).
m. Power Sum Attenuation to Crosstalk Ratio Far-End (PSACR-F).
n. Alien Near-End Cross Talk (ANEXT).
o. Power Sum Alien Near-End Cross Talk (PSANEXT).
p. Alien Far-End Cross Talk (AFEXT).
q. Power Sum Attenuation to Alien Crosstalk Ratio Far-End (PSAACR-F).
r. Average PSANEXT loss.
s. Average PSAACR-F.

D. Testing of Installed Fiber Cabling Links:

1. The installed fiber cabling links shall be tested to meet the requirements of the ANSI/TIA/EIA 568-C and IEC 11801 standards. Measurements shall be done according to EIA/TIA-526-7, -526-14, and -TSB140 standards. The following parameters shall be tested for all fibers in each cable and for all splices, termination, and connections:
   a. Fiber continuity and length at both ends.
   b. Attenuation (optical power loss) in both directions from the ends of each cable.
   c. Polarity.
   d. Splice loss.
   e. Fiber termination endface inspections.
   f. End-to-end optical quality test with Optical Time Domain Reflectometer (OTDR).

E. Ethernet Network Test Requirements:

1. The Contractor shall perform a network walk-through to verify that all applicable installation specifications and environmental classifications were followed. The Contractor shall perform a visual inspection of all cable terminations (fiber and copper).
2. The installed Ethernet Network System shall be tested for performance and functionality according to the IETF RFC 2544 recommendations. The performance of each network link shall be measured in both directions. The duration of each test trial shall be at least 60 seconds. The following minimum tests shall be performed:

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a. Throughput: The maximum rate at which frames can be transmitted from the source to the destination with zero lost frames or errors.
b. Latency: The total time it takes for a frame to travel from source to destination. The minimum, average, and maximum latency values for each frame size shall be reported.
c. Frame Loss: The percentage of frames transmitted that are not received at the destination.
d. Back-to-Back Frames (burstability): The maximum number of frames that can be sent from the source to the destination within a specified interval with zero lost frames.
e. Jitter: The variation in the arrival time of frames received at the destination.
f. Bit Error Rate: The percentage of bit errors measured at the destination relative to the number of bits sent by the source.
g. Verification of the Link Integrity Status LED on both sides of each link.
h. Verification of proper operation and failover of each redundant component and links.
i. Verification of alarming of each link failure.
j. Verification of configuration parameters for each network component (IP addressing, VLAN and port assignment, speed/duplex settings).
k. Verification of the necessary network services including but not limited to DHCP, DNS, FTP, and HTTP.

3. Upon completion and testing of the installed network, the Contractor shall submit test reports in printed form. Test reports shall show all test results performed by the Contractor for each port and piece of equipment. Date of test equipment calibration shall also be provided.

F. Network Troubleshooting: The Contractor is responsible for trouble-free and reliable network installations. The Contractor shall employ any means necessary to ensure operational networks. The Contractor shall obtain any needed test equipment, including but not limited to time-domain reflectometers, protocol analyzers and network sniffers, to troubleshoot any problems. The Contractor shall utilize the services of a trained and certified Network Engineer that is regularly involved in troubleshooting network problems, in the event that operational or reliability problems exist.

END OF SECTION

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SECTION 28 13 00
SECURITY SYSTEMS

PART 1 GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Contract Documents and Division 1 Sections, apply to this Section.

1.02 RELATED SECTIONS

A. Related sections include the following:

1. Division 1, General Requirements.
2. Division 8, Openings.
3. Section 26 05 05, Conductors.
4. Section 26 05 26, Grounding and Bonding for Electrical Systems.
5. Section 26 43 00, Transient Voltage Suppression.
6. Section 32 31 13, Chain Link Fences and Gates.
7. Section 32 31 15, Gate Operator Systems.

1.03 SUMMARY

A. Section Includes:

1. Security access, intrusion detection, CCTV, and intercom operating system and application software.
2. Access Control, Intrusion detection, CCTV, and intercom component requirements.
3. Security system integration and startup.

1.04 DEFINITIONS

A. ACS: Access Control System.

B. Credential: Data assigned to an entity and used to identify that entity.

C. CCTV: Closed circuit television.

D. GFCI: Ground fault circuit interrupter.

E. IDS: Intrusion Detection System.

F. Identifier: A credential card; keypad personal identification number; or code, biometric characteristic, or other unique identification entered as data into the

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entry-control database for the purpose of identifying an individual. Where this term is presented with an initial capital letter, this definition applies.

G. I/O: Input/output.

H. LAN: Local area network.

I. NVR: Network video recorder.

J. PCI Bus: Peripheral Component Interconnect. A peripheral bus providing a high-speed data path between the CPU and the peripheral devices such as a monitor, disk drive, or network.

K. PDF: Portable Document Format. The file format used by the Acrobat document-exchange-system software from Adobe.

L. PTZ: Pan Tilt Zoom.

M. RAS: Remote access services.

N. RF: Radio frequency.

O. ROM: Read-only memory. ROM data are maintained through losses of power.

P. SCADA System: Plant operating, PLC control system. Not provided as part of the security system.

Q. TCP/IP: Transport control protocol/Internet protocol incorporated into Microsoft Windows.

R. TWAIN: Technology without An Interesting Name. A programming interface that lets a graphics application, such as an image editing program or desktop publishing program, activate a scanner, frame grabber, or other image-capturing device.

S. UPS: Uninterruptible power supply.

T. USB: Universal serial bus.

U. WAN: Wide area network.

V. WAV: The digital audio format used in Microsoft Windows.

W. WMP: Windows media player.

X. Wiegand: Type of communication protocol.

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Y. Windows: Operating system by Microsoft Corporation.

Z. WYSIWYG: What You See Is What You Get. Text and graphics appear on the screen the same as they will in print.

1.05 DESIGN INTENT

A. Access Control System: Provide access control on new man doors as shown on Drawings, and at the main gate, visitor parking lot and secondary entry gate. The gates will open via a card reader, free exit loop, and pushbutton control at the operations building. Access control software will be located on a workstation for enrollment and alarm annunciation.

B. Intrusion Detection System: Provide intrusion detection for man doors where shown on Drawings. The intrusion detection system shall be part of the access control system and tied to the CCTV system for automatic alarm assessment of each zone individually.

C. CCTV System: CCTV cameras shall be located where shown on Drawings and display live video on the CCTV workstation in the operations building, and store recorded video on a rack mounted NVR. The CCTV system shall be integrated with the Intrusion Detection System to facilitate automatic alarm assessment of alarms from the intrusion detection system and man doors. Video playback capability shall also be provided as part of the CCTV software package.

D. Intercom System: Provide an intercom station at the main gate and lobby vestibule that calls back to the intercom master station in the Control Room.

1.06 DESIGN REQUIREMENTS

A. The Subcontractor shall design, install, program, and calibrate a complete and functional security system as described in this Section and as shown on Drawings:

1. Provide security components at locations shown on Drawings. The components shown on Drawings are a minimum. The Subcontractor is responsible for providing any additional components required to make a complete and functional system that meets the functional intent of the Drawings and Specifications.
2. The Subcontractor is responsible for selecting the appropriate wire and cable types to provide a fully functional system. Conduit paths are shown on Drawings for coordination purposes only. It is the responsibility of the Subcontractor to ensure that adequate raceways and boxes are provided before installation. Additional conduit requirements must be coordinated with other trades and submitted to CH2M HILL for review prior to start of Work.

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3. The Subcontractor is responsible for sizing and locating all power supplies required for the security system.
4. The security system shall be capable of handling all locations shown on Drawings, and an additional 25 percent future capacity, including all power supplies.
5. The security system shall have provisions for programming access cards through software provided by the Subcontractor on the access control workstation. This will permit programming of the access control system to grant access to specific doors based on the privileges granted to the holder of that card.
6. The ACS, IDS, and CCTV systems shall be fully integrated to provide a robust security system that is capable of restricting access, initiating intruder alarms, and automatically assessing alarm events by displaying video of the area that initiated the alarm. CCTV coverage shall include:
    a. Provide continuous scan of entire plant yard.
    b. Provide continuous scan of building until alarm is set.
    c. Provide continuous scan of building on alarm until alarm is cleared.
    d. Pan to opened door on valid card.
    e. At a minimum, send still shots to Fort Defiance, continuous video is the goal, depending on bandwidth availability.

1.07 SUBMITTALS

A. Action Submittals:

1. Product Data: Provide manufacturer's cut sheets for each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Reference each product to a location on Drawings.
2. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
    a. Diagrams for cable management system.
    b. Detailed Point to Point Wiring Diagrams. Showing all power, signal, and control wiring including routing and termination points on each device.
    c. Battery and charger calculations for security panels.
    d. Programming Matrix: Showing how all components will operate.
    e. Power supply calculations showing that they are capable of handing power consumption including 25 percent future capacity.
    f. Anchorage and bracing drawings and catalog information, as required by Section 01 88 15, Anchorage and Bracing, for loads in Section 01 61 00, Common Product Requirements.

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B. Informational Submittals:

1. Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing, for loads in Section 01 61 00, Common Product Requirements.
2. Operation and Maintenance Data: For security system to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 01 78 23, Operation and Maintenance Data, include the following:
   a. Hard copies of manufacturer's specification sheets, operating specifications, design guides, user's guides for software and hardware, and PDF files on CD-ROM of the hard-copy submittal.
   b. System installation and setup guides with data forms to plan and record options and setup decisions.
3. Test Reports: Final test reports showing that the system has been programmed calibrated and operates as intended.

1.08 QUALITY ASSURANCE

A. Installer Qualifications: An employer of workers trained and approved by manufacturer.

1. Cable installer must have on staff a registered communication distribution designer certified by Building Industry Consulting Service International.

B. Source Limitations: Obtain controllers, Identifier readers, and all software through one source.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. Comply with NFPA 70, National Electrical Code.

E. Comply with SIA DC-01, SIA DC-03, and SIA DC-07.

1.09 DELIVERY, STORAGE, AND HANDLING

A. Electronic Components:

1. Store in temperature- and humidity-controlled environment in original manufacturer's sealed containers. Maintain ambient temperature between 50 and 85 degrees F (10 and 30 degrees C), and not more than 80 percent relative humidity, noncondensing.

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2. Open each container; verify contents against packing list; and file copy of packing list, complete with container identification, for inclusion in operation and maintenance data.
3. Save original manufacturer's containers and packing materials and deliver as directed under provisions covering extra materials.

1.10 PROJECT CONDITIONS

A. Environmental Conditions: System shall be capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:

1. Indoor, Controlled Environment: NEMA 250, Type 12 enclosure. System components installed in temperature-controlled indoor environments shall be rated for continuous operation in ambient conditions of 36 to 122 degrees F (2 to 50 degrees C) dry bulb and 20 to 90 percent relative humidity, no condensing.
2. Enclosures Installed Outdoors or Indoors in Spaces that are Not Conditioned:
    a. For enclosures with electronic components when noted or if required to meet panel components temperature ratings:
        1) Provide NEMA 4X side-mounted or top-mounted closed-loop air conditioning unit. Size the unit to maintain temperatures inside the enclosure to no more than 45 degrees C with an ambient temperature of 50 degrees C in full sun, derated for an altitude of 2,250 feet, and the equipment operating at full load.
        2) Air Conditioner Power: 120 volts, provided by an external circuit, for loads not to exceed 15A. For loads greater than 15A at 120-volt, notify CH2M HILL and request direction.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Access Control System: Millennium Group.

B. CCTV System: March Networks.

C. Intercom System:

1. Aiphone.
2. Approved equal.

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2.02 DESCRIPTION

A. Access Control System: Network type system, server and workstation based front end and field-installed controllers, connected by a high-speed electronic-data transmission network.

B. Intrusion Detection System: Door status contacts, as part of ACS system and integrated with CCTV workstations for alarm display and assessment.

C. Closed Circuit TV System: Network type system, fixed and PTZ color IP cameras, network video recorder, and video displayed on CCTV workstation. Capable of automatic assessment of intrusion detection system upon receiving an alarm.

D. Intercom System: Network type system, intercoms at the main gates and vestibule that call back to the intercom master in the operations building.

2.03 SECURITY FRONT END

A. ACS Workstation:

1. Fully functional workstation capable of report and event printing, enrollment, and alarm assessment. Workstation requirements shall meet or exceed manufacturers minimum specifications and Owners IT standards, including, but not be limited to the following:
   a. Manufacturer.
   b. Operating system requirements.
   c. RAM requirements.
   d. Processing requirements.
   e. Disk space requirements.
2. Software Requirements: The Subcontractor shall install the following fully functional software packages on the workstation. It is the Subcontractor's responsibility to ensure that the software being installed is compatible with the hardware systems being provided:
   a. Access Control Software: Millennium Group.

B. CCTV Workstation:

1. Fully functional workstation capable of display of CCTV camera video. Workstation requirements shall meet or exceed manufacturers minimum specifications and Owners IT standards, including, but not be limited to the following:
   a. Manufacturer.
   b. Operating system requirements.
   c. RAM requirements.
   d. Processing requirements.
   e. Disk space requirements.

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2. Software Requirements: The Subcontractor shall install the following fully functional software packages on the reception workstation provided by other. It is the Subcontractor's responsibility to ensure that the software being installed is compatible with the hardware systems being provided:
    a. CCTV Software: March Networks Command software.

C. ACS Server: Connect to existing Millenium Group access control server at Fort Defiance.

D. CCTV Server:

1. Fully functional server capable of managing CCTV functions and integrating with access control server. Server requirements shall meet or exceed manufacturers minimum specifications and Owners IT standards, including, but not be limited to the following:
    a. Manufacturer.
    b. Operating system requirements.
    c. RAM requirements.
    d. Processing requirements.
    e. Disk space requirements.
    f. Rack Mountable.
2. Software Requirements: The Subcontractor shall install the following fully functional software packages on the reception workstation provided by other. It is the Subcontractor's responsibility to ensure that the software being installed is compatible with the hardware systems being provided:
    a. CCTV Software:
        1) March Networks Command Enterprise software.
        2) Database software, such as SQL server.

E. Network Video Recorder (NVR):

1. Fully functional recording server. Server shall meet or exceed manufacturers minimum requirements and Owners IT standards, including, but not be limited to the following:
    a. Rack Mountable.
    b. Operating system requirements.
    c. RAM requirements.
    d. Processing requirements.
    e. Disk space requirements: 10 days storage for all cameras at 10 frames per second with higher frame rates for alarm and tours.
    f. Space for 25 percent growth.
    g. Rack mountable.
2. Manufacturer: March Networks Model No. 9132 series, or equal.

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2.04 ACCESS CONTROL SYSTEM OPERATION

A. Security access system shall use a single database for access-control and credential-creation functions.

B. Distributed Processing: A fully distributed processing system.

1. Access-control information, including time, date, valid codes, access levels, and similar data, shall be downloaded to controllers so each controller can make access-control decisions.
2. In the event that communications with the front end are lost, controllers shall automatically buffer event transactions until communications are restored, at which time buffered events shall be uploaded to the front end.

C. Location Capacity:

1. Number reader-controlled doors shown on Drawings plus 25 percent.
2. Access credentials provided by Owner.
3. Number of supervised alarm inputs shown on Drawings plus 25 percent.
4. Number programmable outputs shown on Drawings plus 25 percent.

D. System Network Requirements:

1. System components shall be interconnected and shall provide automatic communication of status changes, commands, field-initiated interrupts, and other communications required for proper system operation.
2. Communication shall not require operator initiation or response and shall return to normal after partial- or total-network interruption such as power loss or transient upset.
3. System shall automatically annunciate communication failures to the operator and shall identify the communications link that has experienced a partial or total failure.
4. Communications controller may be used as an interface between the front-end system and the field device network. Communications controller shall provide functions required to attain the specified network communications performance.

E. Field equipment shall include controllers, sensors, and controls.

1. Controllers shall serve as an interface between the front end and sensors and controls.
2. Data exchange between the front end and the controllers shall include down-line transmission of commands, software, and databases to controllers.

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3. The up-line data exchange from the controller to the front end shall include status data such as intrusion alarms, status reports, and entry-control records.
4. Controllers are classified as alarm-annunciation or entry-control type.

F. System Response to Alarms:

1. Field device network shall provide a system end-to-end response time of 1 second or less for every device connected to the system.
2. Alarms shall be annunciated at the front end within one second of the alarm occurring at a controller or at a device controlled by a local controller, and within 100 ms if the alarm occurs at the front end.
3. Alarm and status changes shall be displayed within 100 ms after receipt of data by the front end.
4. This response time shall be maintained during system heavy load.
5. Opening of a door using an authenticated card shall shunt the BMS and not generate an alarm. Card reader, electric door strike, and BMS shall be calibrated accordingly.

G. False-Alarm Reduction: The design of the front end and controllers shall contain features to reduce false alarms. Equipment and software shall comply with SIA CP-01.

H. Error Detection:

1. Use a cyclic code method to detect single- and double-bit errors, burst errors of 8 bits or fewer, and at least 99 percent of all other multibit and burst errors between controllers and the front end.
2. Interactive or product error-detection codes alone will not be acceptable.
3. A message shall be in error if one bit is received incorrectly.
4. Retransmit messages with detected errors.
5. Allow for an operator-assigned two-digit decimal number to each communications link representing the number of retransmission attempts.
6. Front end shall print a communication failure alarm message when the number of consecutive retransmission attempts equals the assigned quantity.
7. Monitor the frequency of data transmission failure for display and logging.

I. Data Line Supervision: System shall initiate an alarm in response to opening, closing, shorting, or grounding of data transmission lines.

J. Door Hardware Interface:

1. Comply with requirements in Division 8 Sections for door hardware required to be monitored or controlled by the security access system.

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2. For motorized gate requirements, see Section 32 31 15, Gate Operator Systems.
3. Electrical characteristics of controllers shall match the signal and power requirements of door hardware.

2.05 SITE CONTROL UNIT (ACS MODULE)

A. Communication: bi-directional communications to and from server can use either RS-232 or RS-485 protocols.

B. 2000 event history.

C. Power: 9 to 14V dc at 50 mA nominal, 90 mA maximum.

D. UL 294 listed.

E. Manufacturer: Millenium Group, Model No. 149-101117.

1. Include the following accessories:
   a. Surface mount box, Model No. 041-100992.
   b. SEI Site Ethernet interface, Model No. 120-507991.

2.06 DOOR CONTROL DEVICE (ACS MODULE)

A. Controls access for a single door.

B. Communication: RS-485 communications to site control unit.

C. Inputs: Seven7 supervised alarm inputs.

D. Outputs: Two form “C” relay outputs rated ate 2 amps at 24V dc.

E. Integrated on-board tamper.

F. UL 294 listed.

G. Manufacturer: Millenium Group, Model No. 149-100958.

1. Include the following accessories: Surface mount box, Model No. 041-100992.

2.07 POWER SUPPLIES (PS)

A. 12V dc power supply.

1. Mounted in a self-contained, locking enclosure with battery backup.
2. 120-volt, single-phase input.
3. 12V dc, 5 amp continuous output.

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4. Dry contact output for AC failure.
5. Tamper switch.
6. UL 294 listed.
7. Manufacturer: Millenium Group, Model No. PS1-100212-001.

B. 24V dc Power Supply:

1. Mounted in a self-contained, locking enclosure with battery backup.
2. 120-volt, single-phase input.
3. 24V dc, 4 amp continuous output.
4. Dry contact output for AC failure.
5. Tamper switch.
6. UL 294 listed.
7. Manufacturer: Altronix Model No. AL400ULACM, or equal.

2.08 CARD READERS

A. Card-Reader Power: Powered from its associated controller, including its standby power source, and shall not dissipate more than 5 W.

B. Enclosure: Suitable for surface, semi-flush, pedestal, or weatherproof mounting. Mounting types shall additionally be suitable for installation in the following locations:

1. Indoors, controlled environment.
2. Indoors, uncontrolled environment.
3. Outdoors, with built-in heaters or other cold-weather equipment to extend the operating temperature range as needed for operation at the site.
4. Pry-tamper switch integral to the housing.

C. Manufacturer: HID, or approved equal.

2.09 BALANCED MAGNETIC SWITCHES

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Aleph America Corporation.
2. General Electric Company; GE Security, Inc.
3. George Risk Industries.
4. Honeywell International Inc.; Honeywell Security.

B. Description: Balanced-magnetic switch, complying with UL 634, installed on frame with integral overcurrent device to limit current to 80 percent of switch

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capacity. Bias magnet and minimum of three encapsulated reed switches shall resist compromise from introduction of foreign magnetic fields.

1. Flush-Mounted Switch: Unobtrusive and flush with surface of door and window frame.
2. Surface Mounted Switch: Stainless steel armored lead, fully potted. Sentrol 2707A, or approved equal.
3. Overhead Door Switch: Balanced-magnetic type.

2.10 REQUEST TO EXIT DEVICES

A. Proximity Infra-Red type with micro-based signal processing.

B. Adjustable relay time (0.5 to 64 seconds).

C. Detectable walk rate of 0.5 to 10 feet per second.

D. Adjustable “tamper proof” shutters, which provide precise target area.

E. Two Form C outputs.

F. Swivel optics.

G. Green LED indicator.

H. Cover tamper switch.

I. Color: Black.

2.11 INTERCOM STATIONS

A. Compatible with Intercom Adapter being provided.

B. AI Phone: IE-SS, or approved equal.

2.12 INTERCOM ADAPTER

A. Capable of converting intercom signal to Ethernet media.

B. Integral power supply, with 120-volt input.

C. AI Phone: IPW-1A, or approved equal.

2.13 INTERCOM MASTER STATION

A. Audio Master Station.

B. Capable of communicating with the Intercom Stations at the main gate.

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C. Capable of opening the main vehicle and pedestrian gates.

D. Power supply compatible with Master Station being provided.

E. AI Phone AX-8M, or approved equal.

2.14 CCTV CAMERAS

A. Cameras:

1. IP Exterior Day/Night PTZ:
   a. 1280 X 720 (720p) resolution.
   b. Auto-focus.
   c. 18 X zoom.
   d. 30 frames per second.
   e. H.264 and MJPEG compression.
   f. IEEE 802.3at Power over Ethernet.
   g. Color: 74 lux at F1.6.
   h. Black/While: 04 lux at F1.6.
   i. Slip ring for 360-degree continuous rotation.
   j. Presets and autotack feature.
   k. Manufacturer: Axis model number P5534-E.
2. IP Indoor/outdoor 180 Day/Night Fixed:
   a. Two 6 megapixel, 3072x2048 resolution.
   b. 30 frames per second.
   c. H.264 and MJPEG compression.
   d. IEEE 802.3af Power over Ethernet.
   e. Color: 0.1 lux at 1/60 second.
   f. Black/While: 0.02 lux at 1/60 second.
   g. IP66 rated.
   h. Vandal Resistant Housing.
   i. Varifocal Lens.
   j. Manufacturer: Mobotix model number D15.
3. IP Outdoor All Around Day/Night Fixed:
   a. 6 megapixel, 3072 by 2048 resolution.
   b. Lens: 180 degree to 8 degree.
   c. 30 frames per second.
   d. H.264 and MJPEG compression.
   e. IEEE 802.3af Power over Ethernet.
   f. Color: 0.1 lux at 1/60 second.
   g. Black/While: 0.02 lux at 1/60 second.
   h. IP66 rated.
   i. Vandal Resistant Housing.
   j. Manufacturer: Mobotix M25 series.

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4. IP Interior IR Mini-dome Fixed:
    a. 4MP resolution.
    b. Built in IR illuminator.
    c. 30 frames per second.
    d. H.264 and MJPEG compression.
    e. IEEE 802.3af Power over Ethernet.
    f. Color: 1 lux.
    g. Black/While:.01 lux.
    h. Vandal Resistant Housing.
    i. 2.8 or 4mm Lens.
    j. Manufacturer: March Networks ME4 IR series.

2.15 SURGE AND TAMPER PROTECTION

A. Surge Protection: Protect components from voltage surges originating external to equipment housing and entering through power, communication, signal, control, or sensing leads. Include surge protection for exterior wiring of each conductor-entry connection to components.

1. Minimum Protection for Power Connections 120-volt and More: Auxiliary panel suppressors complying with requirements in Section 26 43 00, Surge Protective Devices.
2. Minimum Protection for Communication, Signal, Control, and Low-Voltage Power Connections: Comply with requirements in Section 26 43 00, Surge Protective Devices, as recommended by manufacturer for type of line being protected.

B. Tamper Protection: Tamper switches on enclosures, control units, cabinets, card readers, and other system components shall initiate a tamper-alarm signal when unit is opened or partially disassembled. Control-station control-unit alarm display shall identify tamper alarms and indicate locations.

2.16 CABLES

A. General Cable Requirements: Comply with requirements in Section 26 05 05, Conductors, and as recommended by system manufacturer for integration requirement. Subcontractor only required to submit information on cable types intended to be used on this Project.

B. PVC-Jacketed, TIA 232-F Cables:

1. Two pairs, No. 22 AWG, stranded (7x30) tinned copper conductors, polypropylene insulation, and individual aluminum-foil/polyester-tape shielded pairs with 100 percent shield coverage; PVC jacket.
2. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.

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3. NFPA 70, Type CM.
4. Flame Resistance: UL 1581 vertical tray.

C. Plenum-Type, TIA 232-F Cables:

1. Two pairs, No. 22 AWG, stranded (7x30) tinned copper conductors, plastic insulation, and individual aluminum-foil/polyester-tape shielded pairs with 100 percent shield coverage; plastic jacket.
2. Pairs are cabled on common axis with No. 24 AWG, stranded (7 by 32) tinned copper drain wire.
3. NFPA 70, Type CMP.
4. Flame Resistance: NFPA 262 flame test.

D. PVC-Jacketed, TIA 485-A Cables: Two pairs, twisted, No. 22 AWG, stranded (7x30) tinned copper conductors, PVC insulation, unshielded, PVC jacket, and NFPA 70, Type CMG.

E. Plenum-Type, TIA 485-A Cables:

1. Two pairs, No. 22 AWG, stranded (7 by 30) tinned copper conductors, fluorinated-ethylene-propylene insulation, unshielded, and fluorinated-ethylene-propylene jacket.
2. NFPA 70, Type CMP.
3. Flame Resistance: NFPA 262 flame test.

F. Multiconductor, PVC, Reader and Wiegand Keypad Cables:

1. No. 22 AWG, paired and twisted multiple conductors, stranded (7 by 30) tinned copper conductors, semirigid PVC insulation, overall aluminum-foil/polyester-tape shield with 100 percent shield coverage, plus tinned copper braid shield with 65 percent shield coverage, and PVC jacket.
2. NFPA 70, Type CMG.
3. Flame Resistance: UL 1581 vertical tray.
4. For TIA 232-F applications.

G. Paired, PVC, Reader and Wiegand Keypad Cables:

1. Three pairs, twisted, No. 22 AWG, stranded (7x30) tinned copper conductors, polypropylene insulation, individual aluminum-foil/polyester-tape shielded pairs each with No. 22 AWG, stranded tinned copper drain wire, 100 percent shield coverage, and PVC jacket.
2. NFPA 70, Type CM.
3. Flame Resistance: UL 1581 vertical tray.

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H. Paired, PVC, Reader and Wiegand Keypad Cables:

1. Three pairs, twisted, No. 20 AWG, stranded (7 by 28) tinned copper conductors, polyethylene (polyolefin) insulation, individual aluminum-foil/polyester-tape shielded pairs each with No. 22 AWG, stranded (19 by 34) tinned copper drain wire, 100 percent shield coverage, and PVC jacket.
2. NFPA 70, Type CM.
3. Flame Resistance: UL 1581 vertical tray.

I. Paired, Plenum-Type, Reader and Wiegand Keypad Cables:

1. Three pairs, No. 22 AWG, stranded (7 by 30) tinned copper conductors, plastic insulation, individual aluminum-foil/polypropylene-tape shielded pairs each with No. 22 AWG, stranded tinned copper drain wire, 100 percent shield coverage, and fluorinated-ethylene-propylene jacket.
2. NFPA 70, Type CMP.
3. Flame Resistance: NFPA 262 flame test.

J. Multiconductor, Plenum-Type, Reader and Wiegand Keypad Cables:

1. Six conductors, No. 20 AWG, stranded (7 by 28) tinned copper conductors, fluorinated-ethylene-propylene insulation, overall aluminum-foil/polyester-tape shield with 100 percent shield coverage plus tinned copper braid shield with 85 percent shield coverage, and fluorinated-ethylene-propylene jacket.
2. NFPA 70, Type CMP.
3. Flame Resistance: NFPA 262 flame test.

K. Paired, Lock Cables:

1. One pair, twisted, No. 16 AWG, stranded (19 by 29) tinned copper conductors, PVC insulation, unshielded, and PVC jacket.
2. NFPA 70, Type CMG.
3. Flame Resistance: UL 1581 vertical tray.

L. Paired, Plenum-Type, Lock Cables:

1. One pair, twisted, No. 16 AWG, stranded (19 by 29) tinned copper conductors, PVC insulation, unshielded, and PVC jacket.
2. NFPA 70, Type CMP.
3. Flame Resistance: NFPA 262 flame test.

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M. Paired, Lock Cables:

1. One pair, twisted, No. 18 AWG, stranded (19 by 30) tinned copper conductors, PVC insulation, unshielded, and PVC jacket.
2. NFPA 70, Type CMG.
3. Flame Resistance: UL 1581 vertical tray.

N. Paired, Plenum-Type, Lock Cables:

1. One pair, twisted, No. 18 AWG, stranded (19 by 30) tinned copper conductors, fluorinated-ethylene-propylene insulation, unshielded, and plastic jacket.
2. NFPA 70, Type CMP.
3. Flame Resistance: NFPA 262 flame test.

O. Paired, Input Cables:

1. One pair, twisted, No. 22 AWG, stranded (7 by 30) tinned copper conductors, polypropylene insulation, overall aluminum-foil/polyester-tape shield with No. 22 AWG, stranded (7 by 30) tinned copper drain wire, 100 percent shield coverage, and PVC jacket.
2. NFPA 70, Type CMR.
3. Flame Resistance: UL 1666 riser flame test.

P. Paired, Plenum-Type, Input Cables:

1. One pair, twisted, No. 22 AWG, stranded (7 by 30) tinned copper conductors, fluorinated-ethylene-propylene insulation, aluminum-foil/polyester-tape shield (foil side out), with No. 22 AWG drain wire, 100 percent shield coverage, and plastic jacket.
2. NFPA 70, Type CMP.
3. Flame Resistance: NFPA 262 flame test.

Q. Paired, AC Transformer Cables:

1. One pair, twisted, No. 18 AWG, stranded (7 by 26) tinned copper conductors, PVC insulation, unshielded, and PVC jacket.
2. NFPA 70, Type CMG.

R. Paired, Plenum-Type, AC Transformer Cables:

1. One pair, twisted, No. 18 AWG, stranded (19 by 30) tinned copper conductors, fluorinated-ethylene-propylene insulation, unshielded, and plastic jacket.
2. NFPA 70, Type CMP.
3. Flame Resistance: NFPA 262 flame test.

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S. LAN Cabling:

1. Comply with requirements in Section 26 05 05, Conductors.
2. NFPA 262.

2.17 SURVEILLANCE SIGNS

A. Aluminum, 10 inches by 14 inches, minimum.

B. Sign shall read “RESTRICTED AREA MONITORED BY VIDEO CAMERA”.

PART 3 EXECUTION

3.01 EXAMINATION

A. Examine pathway elements intended for cables. Check raceways, cable trays, and other elements for compliance with space allocations, installation tolerances, hazards to cable installation, and other conditions affecting installation.

B. Examine roughing-in for LAN and control cable conduit systems to PCs, controllers, card readers, and other cable-connected devices to verify actual locations of conduit and back boxes before device installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION

A. Comply with recommendations in SIA CP-01.

B. Comply with TIA/EIA 606-A, Administration Standard for Commercial Telecommunications Infrastructure.

C. Obtain detailed Project planning forms from manufacturer of access-control system; develop custom forms to suit Project. Fill in all data available from Project plans and specifications and publish as Project planning documents for review and approval.

1. Record setup data for workstation.
2. For each Location, record setup of controller features and access requirements.
3. Propose start and stop times for time zones and holidays, and match up access levels for doors.
4. Set up groups, facility codes, linking, and list inputs and outputs for each controller.
5. Assign action message names and compose messages.

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6. Set up alarms. Establish interlocks between alarms, and intruder detection.
7. Develop user-defined fields.
8. Propose setups for key control.
9. Complete system diagnostics and operation verification.
10. Prepare a specific plan for system testing, startup, and demonstration.
11. Develop acceptance test concept and, on approval, develop specifics of the test.
12. Develop cable and asset-management system details; input data from construction documents. Include system schematics and Visio Technical Drawings in electronic format.

D. In meetings with CH2M HILL, present Project planning documents and review, adjust, and prepare final setup documents. Use final documents to set up system software.

3.03 CABLING

A. Comply with NECA 1, Good Workmanship in Electrical Construction.

B. Install cables and wiring according to requirements in Section 26 05 05, Conductors.

C. Wiring Method: Install wiring in raceway except within consoles, cabinets, desks, and counters. Conceal raceway and wiring except in unfinished spaces.

D. Install LAN cables using techniques, practices, and methods that are consistent with Category 6 rating of components and fiber-optic rating of components, and that ensure Category 6 and fiber-optic performance of completed and linked signal paths, end to end.

E. Boxes and enclosures containing security-system components or cabling, and which are easily accessible to employees or to the public, shall be provided with a lock. Boxes above ceiling level in occupied areas of the building shall not be considered accessible. Junction boxes and small device enclosures below ceiling level and easily accessible to employees or the public shall be covered with a suitable cover plate and secured with tamperproof screws.

F. Install end-of-line resistors at the field device location and not at the controller or panel location.

3.04 CABLE APPLICATION

A. Comply with TIA 569-B, Commercial Building Standard for Telecommunications Pathways and Spaces.

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B. Cable application requirements are minimum requirements and shall be exceeded if recommended or required by manufacturer of system hardware.

C. TIA 232-F Cabling: Install at a maximum distance of 50 feet (15 m).

D. TIA 485-A Cabling: Install at a maximum distance of 4,000 feet (1,220 m).

E. Card Readers:

1. Install number of conductor pairs recommended by manufacturer for the functions specified.
2. Unless manufacturer recommends larger conductors, install No. 22 AWG wire if maximum distance from controller to the reader is 250 feet (75 m), and install No. 20 AWG wire if maximum distance is 500 feet (150 m).
3. For greater distances, install "extender" or "repeater" modules recommended by manufacturer of the controller.
4. Install minimum No. 18 AWG shielded cable to readers and keypads that draw 50 mA or more.

F. Install minimum No. 16 AWG cable from controller to electrically powered locks. Do not exceed 250 feet (75 m).

G. Install minimum No. 18 AWG ac power wire from transformer to controller, with a maximum distance of 25 feet (8 m).

3.05 GROUNDING

A. Comply with Section 26 05 26, Grounding and Bonding for Electrical Systems.

B. Comply with IEEE 1100, Recommended Practice for Power and Grounding Electronic Equipment.

C. Ground cable shields, drain conductors, and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.

D. Bond shields and drain conductors to ground at only one point in each circuit.

E. Signal Ground:

1. Terminal: Locate in each equipment room and wiring closet; isolate from power system and equipment grounding.
2. Bus: Mount on wall of main equipment room with standoff insulators.
3. Backbone Cable: Extend from signal ground bus to signal ground terminal in each equipment room and wiring closet.

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3.06 INSTALLATION

A. Push Buttons: Where multiple push buttons are housed within a single switch enclosure, they shall be stacked vertically with each push-button switch labeled with 1/4-inch (6.4-mm) high text and symbols as required. Push-button switches shall be connected to the controller associated with the portal to which they are applied, and shall operate the appropriate electric strike, electric bolt, or other facility release device.

B. Install card readers per manufacturer's recommendations.

3.07 IDENTIFICATION

A. In addition to requirements in this Article, comply with applicable requirements in Section 26 05 05, Conductors, and with TIA/EIA 606-A.

B. Label each terminal strip and screw terminal in each cabinet, rack, or panel.

1. All wiring conductors connected to terminal strips shall be individually numbered, and each cable or wiring group being extended from a panel or cabinet to a building-mounted device shall be identified with the name and number of the particular device as shown.
2. Each wire connected to building-mounted devices is not required to be numbered at the device if the color of the wire is consistent with the associated wire connected and numbered within the panel or cabinet.

C. At completion, cable and asset management software shall reflect as-built conditions.

3.08 SYSTEM SOFTWARE AND HARDWARE

A. Develop, install, and test software and hardware, and perform database tests for the complete and proper operation of systems involved. Assign software license to CH2M HILL.

3.09 FIELD QUALITY CONTROL

A. Perform Tests and Inspections:

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:

1. LAN Cable Procedures: Inspect for physical damage and test each conductor signal path for continuity and shorts. Use Class 2, bidirectional, Category 6 tester. Test for faulty connectors, splices, and

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terminations. Test according to TIA/EIA 568-B.1, Commercial Building Telecommunications Cabling Standards - Part 1: General Requirements. Link performance for UTP cables must comply with minimum criteria in TIA/EIA 568-B.1.

2. Test each circuit and component of each system. Tests shall include, but are not limited to, measurements of power-supply output under maximum load, signal loop resistance, and leakage to ground where applicable. System components with battery backup shall be operated on battery power for a period of not less than 10 percent of the calculated battery operating time. Provide special equipment and software if testing requires special or dedicated equipment.
3. Operational Test: After installation of cables and connectors, demonstrate product capability and compliance with requirements. Test each signal path for end-to-end performance from each end of all pairs installed. Remove temporary connections when tests have been satisfactorily completed.

C. Devices and circuits will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

3.10 STARTUP SERVICE

A. Engage a factory-authorized service representative to supervise and assist with startup service.

1. Complete installation and startup checks according to approved procedures that were developed in Article Preparation, and with manufacturer's written instructions.
2. Enroll and prepare badges and access cards for operators, management, and security personnel.

3.11 PROTECTION

A. Maintain strict security during the installation of equipment and software. Rooms housing the control station, and workstations that have been powered up shall be locked and secured with an activated burglar alarm and access-control system reporting to a central station complying with UL 1610, Central-Station Burglar-Alarm Units, during periods when a qualified operator in the employ of Subcontractor is not present.

END OF SECTION

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SECTION 28 31 00
FIRE DETECTION AND ALARM

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Institute of Electrical and Electronics Engineers (IEEE): C62.41, Surge Voltages in Low-Voltage AC Power Circuits.
2. International Fire Code (IFC).
3. International Building Code (IBC).
4. National Fire Protection Association (NFPA):
   a. 70, National Electrical Code (NEC).
   b. 72, National Fire Alarm Code.
   c. 90A, Standard for the Installation of Air Conditioning and Ventilating Systems.
   d. 101, Code for Safety to Life from Fire in Buildings and Structures.
   e. 820, Fire Protection in Wastewater Treatment and Collection Facilities.
   f. 1221 Standard for the Installation, Maintenance and Use of Emergency Services Communications Systems.
5. National Electrical Manufacturers Association (NEMA): 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
6. National Institute for Certification in Engineering Technologies (NICET).
7. Telecommunications Industry Association (TIA):
   a. 232, Interface Between Data Terminal Equipment and Data Circuit Terminating Equipment Employing Serial Binary Data Interchange.
   b. 485, Electrical Characteristics of Generators and Receivers for Use in Balanced Digital Multipoint Systems.
8. Underwriters Laboratories, Inc. (UL):
   a. 217, Single and Multiple Station Smoke Alarms.
   b. 228, Door Closures-Holders, With or Without Integral Smoke Detectors.
   c. 268, Smoke Detectors for Fire Protective Signaling Systems.
   d. 286A, Smoke Detectors for Duct Application.
   e. 464, Audible Signal Appliances.
   f. 497B, Protectors for Data Communication and Fire Alarm Circuits.
   g. 864, Control Units for Fire-Protective Signaling Systems.
   h. 1449, Standard for Transient Voltage Surge Suppressors.

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i. 1480, Speakers for Fire-Protective Signaling Systems.
j. 1604, Electrical Equipment for Use in Class I and Class II, Division 2, and Class III Hazardous (Classified) Locations.
k. 1638, Visual Signaling Appliances – Private Mode Emergency and General Utility Signaling.
l. 1971, Signaling Devices for the Hearing Impaired.

9. Air National Guard (ANG): ETL 01-1-1, Air National Guard Design Policy.
10. Uniform Fire Code (UFC): 3-600-01, Design: Fire Protection Engineering for Facilities.
11. United State Air Force (USAF):
    a. ETL 01-4, Fire Protection Engineering Criteria – Protective Aircraft Shelters (PAS).
    b. ETL 01-18, Fire Protection Engineering Criteria – Electronic Equipment Installations.
    c. ETL 02-15, Fire Protection Engineering Criteria – New Aircraft Facilities.
    d. ETL 98-8, Fire Protection Engineering Criteria – Existing Aircraft Facilities.
12. Unified Facilities Criteria (UFC): 4-021-01, Design and O&M: Mass Notification Systems.

1.02 DEFINITIONS

A. Addressable: A fire alarm system component with a unique identification that can have its status individually identified or that is used to individually control other functions.

B. AHJ: Authority Having Jurisdiction.

C. CAD: Computer Aided Design.

D. Coded: Audible or visible signal that conveys information about alarm event. Examples are, number of rings of a bell or flashes of a strobe. This could be used to convey location or type of alarm.

E. dB: Decibels.

F. DXF: Drawing Interchange Format.

G. ECP: Environmental Control Panel.

H. FACP: Fire Alarm Control Panel.

I. HVAC: Heating, Ventilating, and Air Conditioning.

J. I/O: Input/Output.

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K. LCD: Liquid Crystal Display.

L. LED: Light-Emitting Diode.

M. MOV: Metal Oxide Varistor.

N. RAM: Random Access Memory.

O. SOM: Sequence of Operations Matrix.

P. Zone: A defined area within the protected premises. A zone can define an area from which an alarm signal can be received or an area to which a signal can be sent. The term zone is typically used when describing conventional, nonaddressable systems.

1.03 SYSTEM DESCRIPTION

A. Design Requirements:

1. Contract Drawings show location of fire alarm panel(s) annunciator panel(s), duct detectors,. Other component locations and quantities shall be determined by fire alarm system installer and shall be included as part of their design. This includes, but is not limited to, smoke detectors, heat detectors, manual pull stations, and notification appliances. Design and installation shall meet requirements of the local AHJ.
2. Contract Drawings show location of fire alarm system components.
3. Design, coordinate, and provide system in accordance with building codes indicated in Section 01 61 00, Common Product Requirements.
4. Design conduit layout and wiring interconnection of devices specified herein, and for interconnection of flow and supervisory switches and alarm bells specified in Section 21 13 00, Fire-Suppression Sprinkler Systems, and Section 21 30 01, Diesel Fire Pump System and Accessories.
5. Coordinate, and include in design, requirements for interfacing with HVAC system.
6. Equipment suitable for addressable fire alarm system.

B. Performance Requirements:

1. Actuation of alarm (smoke or heat detector, flow switch, or other normally open initiating device contact) or trouble (trouble or supervisory switch) shall cause the following operations:
   a. Audible and visual indications of alarmed devices on fire alarm control panel display, and on remote annunciator.

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b. For remote buildings with subpanels, transmit common alarm or trouble signal to light appropriate zone lamp at master fire alarm control panel.
c. Master fire alarm control panel shall transmit common alarm or trouble signal to local Fire Department.

2. Actuation of duct smoke detectors shall, send signal (contact closure) to environmental control panel (ECP) to shut off HVAC equipment and send a Supervisory Alarm to the fire control panel. Fan equipment shall shutdown in accordance with Section 23 09 00, Instrumentation and Control Devices for HVAC.
3. Actuation of sprinkler flow switch shall alarm at panel.
4. Sequence of Operations Matrix at the End of Section describes functions of fire alarm system.

1.04 SUBMITTALS

A. Action Submittals:

1. Descriptive product information for each individual system component.
2. Dimensional drawings of panels and associated equipment.
3. Itemized bill of material.
4. Operating and programming instructions.
5. Control panel configuration and module data.
6. Complete point to point wiring diagrams of system and device interconnection. Identify spare connection points.
7. Alarm initiating, indicating, and supervisory device electrical data.
8. Annunciator configuration and module data.
9. Plans showing device and panel locations as well as conduit and cable sizes. Prepare drawings and diagrams on drawing sheets of uniform size without extraneous information. Marked up electrical, HVAC, lighting or similar drawings or copies of catalog data sheets are not acceptable in lieu of required drawings or diagrams.
10. Sequence of Operation Matrix.
11. Battery sizing calculations.
12. Supervisory power requirements for equipment.
13. Alarm power requirements for equipment.
14. Power supply rating justification showing power requirements for system power supplies.
15. Voltage drop calculations for wiring runs, demonstrating worst case condition.
16. Conduit fill calculations.
17. Sample warranty.
18. Recommended types and quantities for spare parts.
19. For each system’s control panel, provide written schedule of active and spare addresses provided on each addressable circuit.

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20. Seismic anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.

B. Informational Submittals:

1. Experience and qualifications of firm(s) proposed to design and install system.
2. Certifications documenting service technician's training. Certification shall indicate name of individual, training, dates, systems qualified, and current status.
3. Seismic anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
4. Component and attachment testing seismic certificate of compliance as required by Section 01 45 33, Special Inspection and Testing.
5. Copy of design documents, Shop Drawings, and calculations submitted to code-enforcement authorities.
6. Code-enforcement authority approval letter.
7. Factory test reports.
8. Detailed program and schedule for testing, inspection, and maintenance of fire alarm system that satisfies requirements of NFPA 72, manufacturer's recommendations, and local authority having jurisdiction.
9. System program hard copy and CD-ROM showing system functions, controls, and labeling of equipment and devices.
10. Documentation of system voltage, current, and resistance readings taken during installation, testing, and ATP phases of system installation.
11. System record drawings and wiring details including one set of reproducible masters and drawings on CD-ROM in a DXF format suitable for use in a CAD drafting program.
12. NFPA 72, Record of Completion: Submit to Owner and code-enforcement authorities.
13. NFPA 72, Inspection and Testing Form: Submit to Owner and code enforcement authorities.
14. Operation and Maintenance Data as specified in Section 01 78 23, Operation and Maintenance Data.

1.05 QUALITY ASSURANCE

A. Qualifications:

1. Provide names of projects, locations, and telephone numbers of persons to contact for at least two installations where Contractor or Subcontractor has installed detection and alarm systems that are similar in size and scope as this.
2. System design, installation and testing shall be performed by licensed firm(s) with established reputation in fire alarm system industry having

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5 years' experience in design, installation, and testing of fire alarm systems.

3. Technician with minimum of NICET Level II Certification for fire alarm systems or professional engineer registered in State of New Mexico shall be available onsite.
4. Service technician shall be formally trained by manufacturer.

1.06 SPECIAL GUARANTEE

A. Provide manufacturer's extended guarantee or warranty, with Owner named as beneficiary, in writing, as special guarantee. Special guarantee shall provide for correction, or at the option of the Owner, removal and replacement of Work specified in this Specification section found defective during a period of 2 years after the date of Substantial Completion. Duties and obligations for correction or removal and replacement of defective Work shall be as specified in the General Conditions.

1.07 MAINTENANCE

A. Maintenance Service: For 2 years after Correction Period, provide maximum of 2 service calls, at Owner's request, to make adjustments or repairs required to keep system in satisfactory, full operation.

1.08 EXTRA MATERIALS

A. Furnish, tag, and box for shipment and storage the following spare parts, special tools, and material:

Item	Quantity
Special tools required to maintain or dismantle	One complete set for each different size unit

B. Delivery: In accordance with Section 01 61 00, Common Product Requirements.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Materials, equipment, and accessories specified in this section shall be products of:

1. Siemens Building Technologies.
2. Simplex/Grinnell.
3. FCI.

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4. Notifier Fire Systems.
5. Edwards Systems Technology.

2.02 GENERAL

A. Material and equipment shall be standard products of their respective manufacturers, and shall be of a model that has been in production for not less than 3 years. Equipment shall be supported by a service organization that is, in the opinion of Owner, reasonably convenient to Site.

B. Contractor shall become familiar with details of Project, verify dimensions in field, and revise conduit and equipment locations to avoid obstructions and allow installation of new equipment.

C. Contractor shall not begin system installation prior to receiving written approval of Shop Drawings from Engineer.

2.03 UL COMPLIANCE

A. Products manufactured within scope of Underwriters Laboratories, Inc. shall conform to UL Standards and have an applied UL listing mark.

B. Equipment shall be UL listed in accordance with requirements of NFPA.

2.04 SERVICE CONDITIONS

A. Altitude: Not greater than 3,300 feet above sea level.

B. Ambient Temperature:

1. Maximum 40 degrees C.
2. Minimum 0 degrees C.

C. Equipment shall be fully rated without derating for these conditions.

2.05 POSTED OPERATING INSTRUCTIONS (POI)

A. POIs shall be prepared on full size drawing sheets.

B. POIs shall be framed in extruded metal frames, mounted under glass and shall be water/weather resistant. Instructions shall be permanently mounted on reserved wall area in space shown on Drawings.

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C. POIs shall include:

1. Facility floor plans showing location of fire equipment and devices with coordinated identification. Show items such as firewalls, fire dampers, and fire alarm devices.
2. Fire alarm wiring diagrams and schematics, with zone identification and device address list.

2.06 FIRE ALARM CONTROL PANELS

A. General:

1. Control panel circuit for 24V dc, power limited, initiating circuits per NFPA 70, Article 760.
2. Assembled panel UL 864 listed Product Category UOJ2, as an integrated control system.
3. Enclosure:
   a. NEMA 250 Type 1.
   b. Color: Red.
4. Internally Mounted Module with:
   a. Transformer with 120 V ac input and 21.5V ac output.
   b. Solid state rectifier for 21.5V ac input and fuse protected, filtered, and regulated 26V dc no-load output.
   c. Solid state transfer switch, minimum 8 amp-hours.
   d. Standby batteries sized for system operating period of 24 hours of standby mode operation.
   e. Solid state battery charger.
   f. Over/under voltage monitor supervisory circuit.
   g. LEDs for status of normal power, battery trouble, and power supply module trouble.
   h. Alarm mode of 5 minutes after standby operation.
5. Local differentiating audible sound device for alarm, trouble, and supervisory conditions.
6. Full digital transmission protocol.
7. Addressable signal transmission protocol to be either digital pole/response protocol or proprietary communication protocol, with all antilog sensing device signals digitally transmitted to control panel.
8. For addressable systems provide additional 20 percent capacity for future indicating and initiating devices.
9. EMI/RF Protection:
   a. Protect control equipment, devices, and wiring against unwanted radiated electro-magnetic interference (EMI) and from affects of audio and radio frequencies (RF) that can cause transmission of spurious alarms.

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b. System shall be designed and installed so as to be unaffected (with control cabinet faceplates installed) by operation of handheld, portable radios of up to 5 watts, or portable cellular telephones up to 1 watt, within 12 inches of system components.

B. Three-Mode Control Panel:

1. Alarm, supervisory, and trouble modes of operation.
2. Modular construction with solid state microprocessor-based components and central processing unit, continuously scanning each module for status change.
3. Noncoded, fire alarm system with Class A initiating device circuits and Class A notification appliance circuits.
4. Operator Interface Panel:
   a. Indicators, control switches, and tone device.
   b. LCD or digital display to indicate event type and zone location or LEDs with differentiating color lenses for:
      1) AC power on.
      2) Power trouble.
      3) System trouble.
      4) Supervisory alarm.
      5) Earth-ground trouble.
      6) Alarm for each zone.
      7) Trouble for each zone.
      8) Alarm signaling circuit trouble.
      9) Annunciator circuit trouble.
   c. Control Switches for:
      1) Alarm silence.
      2) System reset.
      3) Trouble signal silence and ring-back feature.
      4) Municipal connection circuit disconnect.
      5) Manual evacuation drill.
      6) Auxiliary one bypass.
      7) Auxiliary two bypass.
   d. Piezo-electric tone device with pulsed march time rate for alarm and continuous for trouble conditions.
5. Separate annunciator outputs rated 2-milliamperes supervisory and 120-milliamperes alarm.
6. Smoke Detector Output:
   a. Two- or four-wire as required, rated 2 amperes, 24V dc.
   b. Interrupted when system is reset.
7. Supervised remote inputs for alarm silence and system reset.
8. Switch Selectable:
   a. System diagnostic tests.
   b. Alarm verification.

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c. Alarm silence inhibit.
d. March time alarm code at cadence of 120 beats per minute.
e. Temporal alarm code repeated at 1/2-second on and off intervals.
f. Signal alarm circuit cutout.
g. Water flow and sprinkler supervisory.
h. Sprinkler supervisory.
i. Manual evacuation.
j. Selective signaling.

9. Two alarm and one trouble, Form C auxiliary/output relays rated 2 amperes, 30V dc, 0.5 ampere, 120V ac each.
10. Minimum of 4 input zones.
11. Quantity of SUPERVISORY and TROUBLE alarms outputs shall not be less than that indicated in Sequence of Operations Matrix. See Supplement at End of Section.

C. Addressable Control Panel:

1. Modular construction with solid state, microprocessor-based components, programmable central processor unit, back lighted display of primary control status and essential alarm operating conditions, and concealed, maintenance, purpose operator's keypad.
2. With Signaling Line Circuit Class A and Class A Notification Appliance Circuits.
3. Main control module consisting of operator's keyboard/keypad, local and remote communications and supervision capabilities, system control memory, and programming interface.
   a. Two-line, back lighted, 80 alphanumerical LCD characters with:
      1) Visible cursor for entering data information.
      2) Displayable when cabinet door is open.
   b. Primary operators keypad with:
      1) Acknowledge keys and LEDs for system alarm, supervisory service, and system trouble conditions.
      2) Power on LED.
      3) Alarm silence reset keys.
      4) Displayable when cabinet door is closed.
   c. Pass code protected action display keypad for:
      1) Circuit/device enable or disable.
      2) Control on/off.
      3) Test/status.
      4) Auto or manual.
      5) Activate/reset.
      6) Display historical logs/real time.
      7) Function/menu.
      8) Program.

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9) Delete.
10) Displayable when cabinet door is open.

d. Numerical entry and selection keypad, used in conjunction with action display keypad, to perform control function on system zones, initiating circuits, or auxiliary relays, and to gain access to system information. Displayable when cabinet door is closed.

e. Programmable control keypad with five pass code keys, associated LEDs, and identification labels for:
1) Displayable when door is open.

f. Four function keys for control of variable functions related to primary operations keypad, displayable when door is open.

4. TIA 485, NFPA 72, Style 4, Style 6, or Style 7 data circuit capability for remote annunciators.
5. Form C relay contacts rated 2 amperes, 24V dc.
6. Down loader port for connection to microprocessor-based transponder.
7. Power supply interface module generating digital voltage and current data to LCD with:
   a. dc power conversion and output terminals.
   b. Supervision and control of power supply.
8. Modules with coded input on first alarm, local trouble LED, and in/out capabilities for:
   a. 120 addressable initiating alarm sensors consisting of analog/addressable or traditional detector methods.
   b. Four hardwired I/O points, field selectable in any combination to be either NFPA 72, Style B or Style D, initiating device circuits or NFPA 72, Style Y or Style Z, indicating appliance circuits or auxiliary control circuits.
   c. Auxiliary control circuit contacts shall be single-pole, double-throw, rated 2 amperes at 24V dc and 0.5 amperes at 120V ac.
9. Auxiliary control circuit contacts shall be single-pole, double-throw rated, 2 amperes at 24V dc and 0.5 ampere at 120V ac.
10. Two isolated TIA 232 communication port modules.

2.07 CENTRAL PROCESSING CONTROL PANEL

A. Modular construction with solid state, microprocessor-based programmable control processor, printer, operator console, and 10 levels of priorities for staging of system events.

B. Operator Panel:

1. 80-character, 2-line, LCD display.
2. Individual keys for location information, silence signal, and detector reset.

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3. Lamp test pushbutton with associated LED.
4. Priority and trouble alarm light-emitting diode and associated acknowledge pushbuttons.

C. Examine pushbuttons for “Monitor On” and activating control points.

D. Keyboard consisting of 48 keys labeled with letters, numbers, and options for programming and operational commands.

E. Printer with thermal print head for 20-column record system events produced in 80-column format.

F. Input/output ports as required for TIA 232 communication to local UL listed printer.

G. Selectable alarm verification and distribution processing.

H. Capable of interfacing with remote panels connected to hardwire circuits with:

1. Analog/addressable or traditional detectors.
2. Either normally open or normally closed contacts.
3. Supervised and 24V dc operated fire alarm signaling circuits.
4. Supervised and operated telephone circuits.
5. Capable of interfacing with NFPA 72, hard-wired, Style B and Style D, initiating device circuits and NFPA 72, hard-wired, Style Y and Z, indicating appliance circuits.
6. Network capability.

2.08 LED LIGHTED ANNUNCIATOR

A. Modular constructed illuminated, with group mounted LEDs installed in cabinet having lockable, full hinged door panel, and red baked enamel finish.

B. Rectangular LED units extending through black modular insert with 2 red LEDs per module, engraved zone identification nameplate above each lamp, group mounted with quick disconnect harness, and attached to door by concealed fasteners.

1. Nameplates:
   a. 1/2 inch high by 1-1/2 inches wide.
   b. Two lines with 11 maximum, 3/32-inch high engraved letters and spaces per line.
   c. Black plate surface with white engraved letters.

C. LED test feature with one test switch mounted on cabinet back plate for group test of LEDs on each module.

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2.09 ADDRESSABLE DETECTOR BASE

A. Solid state circuitry with integral LED visual alarm, dip switch or program selectable addressing, and common base receptacle for ionization, photoelectric, and heat detectors. Device address shall be located in base.

B. Constantly monitors detector status and status changes.

C. Suitable for mounting on standard outlet box.

2.10 INDIVIDUAL ADDRESSABLE MODULE

A. Solid state circuitry with selectable latch/nonlatch operating conditions and mounting plate.

B. Monitors single and multiple devices with dry contacts.

C. Suitable for installing inside 4-inch by 4-inch by 2-1/2-inch electrical box.

2.11 ZONE ADDRESSABLE MODULE

A. Monitor module with solid state circuitry for Class A circuits serving dry contact initiating devices.

B. Signal module with solid state circuitry for supervising and operating Class A circuits serving 24V dc signals, speakers, and telephone devices.

C. Module complete with mounting plate, suitable for installation in 4-inch by 4-inch by 2-1/2-inch electrical box having 1-1/2-inch deep extension ring.

2.12 INITIATING DEVICE

A. Pull Station, Fire:

1. Constructed of red molded polycarbonate material or die-cast metal with baked red enamel finish, and raised white letters stating “FIRE.”
2. Surface-mounted with hinged front cover having keyed or allen-wrench reset lock.
3. Where required, rated for use in hazardous environments.
4. Recessed pull handle for single action lift door and pull handle for double action operating station with plastic break rod.
5. Activated station pull handle, latched in protruding position until reset by key.
6. Stations keyed alike with fire alarm control panel.
7. Manual Pull Station: Microprocessor-based communication circuit address, and compatible with fire alarm control panel.

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B. Smoke Detector:

1. Ionization or Photoelectric type with plug-in, twist-lock addressable base per UL 217 and UL 268.
2. Solid state circuitry, sensing chamber, suitable for device releasing service.
3. Concealed, field adjustable, sensitivity test switch.
4. LED; pulsed indication for power availability and steady indication for activated detectors.
5. Self-Compensating Circuitry:
    a. Voltage Range: 15V dc to 30V dc, 24V dc nominal.
    b. Temperature Range: 0 degrees C to 38 degrees C.
    c. Operating Temperature Range: Minus 10 degrees C to 50 degrees C.
    d. Humidity Range: 0 to 95 percent relative humidity.
6. Detectors equipped with insect screen.
7. Photoelectric sensors adjusted to within 3 percent of UL 217 window obturation sensitivity value.

C. Intelligent Fire Detectors:

1. Photoelectric and thermal detector software programmable from fire alarm control panel to match specific hazards and reduce nuisance tripping.
2. Addressable base to be field mounted on octagon box.
3. Software programmable to provide pre-alarm notification.
4. Capable of producing alarm from photoelectric detector, thermal detector, or microprocessor logic.
5. Field cleanable chamber with replaceable chamber components.
6. LED in base to provide status; Pulsed green for normal status, flashing amber for fault or fail condition, and flashing red for alarm.
7. Detector suitable for use in a corrosive environment.

D. Air Duct Smoke Detector:

1. Duct mounted housing with prealigned sampling and exhaust tubes, analog sensing, solid state circuitry, and plug-in, twist-lock addressable base for photoelectric detector in accordance with UL 286A, NFPA 72, NFPA 90A, and NFPA 101.
2. Sampling tubes to extend full width of branch air return duct.
3. Self-Compensating Circuitry:
    a. Voltage Range: 15V dc to 30V dc, 24V dc nominal.
    b. Temperature Range: 0 degrees C to 38 degrees C.
    c. Humidity Range: 10 percent to 90 percent relative humidity.
    d. Velocity Range: 400 feet to 4,000 feet per minute.

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4. Front mounted LED with pulsed indication for alarm condition.
5. Normally open, single-pole, double-throw auxiliary relay with 2 amperes, 28V dc rated contacts for resistive loads.

2.13 ALARMS

A. Audible Alarm:

1. General:
   a. Polarized, 24V dc device with sound power measured dB in accordance with UL 464.
   b. Separate in/out wire leads for field connections.
   c. Baked red enamel finish.
   d. Audibility: In accordance with NFPA 72 and local requirements.
2. Modular Horn:
   a. Surface basic unit, complete with single projector, designed for mounting on 4-inch square electrical box.
   b. Manufacturer supplied box with flush grille plate and basic surface unit for recessed horns.
3. Modular Bell: Vibrating or Single stroke basic unit complete with gong designed for mounting on 4-inch weatherproof electrical box.
   a. tone.
4. Single protection type bell with weatherproof housing, rated for 120V ac motor, adjustable mounting bracket, and audible output of 115 dB.

B. Visual Alarm, Fire:

1. Polarized, 24V dc, multi-candela indicating output per UL 1638.
2. Solid state circuitry for high intensity control of xenon flashtube.
3. Tamper-proof, translucent molded, polycarbonate, pyramidal shaped lens with “FIRE” in red lettering visible from 180-degree viewing field; red enclosure.
4. Polarized in/out wiring.
5. Designed for mounting on wall, single-gauge electrical box, or as part of audible/visible base housing.

2.14 WIRING

A. AC power wiring shall meet requirements of Section 26 05 05, Conductors.

B. Low voltage wiring shall be solid copper or bunch tinned (bonded) stranded copper, minimum 14 AWG, and shall meet NEC Article 760 for nonpower limited service.

C. Network or addressable loop cables shall be as recommended by manufacturer for installation of their system and UL Listed for Fire Alarm Systems.

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2.15 RACEWAYS

A. Conduit used for installation of Fire Alarm system shall follow requirements as identified in Section 26 05 33, Raceway and Boxes.

2.16 END-OF-LINE RESISTORS

A. Ohmic value and power rating as determined by manufacturer based upon number of circuit devices supplied and circuit configuration as installed.

2.17 SURGE SUPPRESSORS

A. Transient Voltage Surge Suppressors (TVSS):

1. Provide to suppress voltage transients that might damage fire alarm panel/transmitter components. Unit shall wire in series to power supply of protected equipment with screw terminations.
2. Unit shall be UL 1449 listed with a 330-volt suppression level and have a maximum response time of 5 nanoseconds.
3. Unit shall meet IEEE C62.41 Category B tests for surge capacity.
4. Features:
   a. Multi-stage construction that includes inductors and silicon avalanche Zener diodes.
   b. Long life indicator lamp (LED or neon lamp) which extinguishes upon failure of protection components. Fusing shall be externally accessible when this feature is available.
5. Manufacturer and Product: Edco of Florida, Ocala, FL; Model HSP-121BT2.

PART 3 EXECUTION

3.01 GENERAL

A. Coordinate with other trades for mounting and interfacing with fire alarm system related devices.

B. Install control panels, initiating and alarm devices, conduit, and wiring for interconnection of devices specified herein and for interconnection of flow and supervisory switches and alarm bells specified in Section 21 13 00, Fire-Suppression Sprinkler Systems for complete and operable system.

3.02 INSTALLATION

A. Install and connect fire detection and alarm equipment in accordance with manufacturer's instructions and recommendations, and in accordance with applicable codes and standards.

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B. Mount devices in accordance with manufacturer's instructions.

C. Provide outlet and junction boxes that are compatible with raceway system.

D. Mount detector LEDs so they are readily visible from floor.

E. Program or configure panels and devices, as required to operate as defined by Sequence of Operations Matrix included as Supplement at End of Section.

F. Install conductors in accordance with Section 26 05 05, Conductors, and NFPA 70, Article 760.

G. Install initiating alarm, signal, and communication conductors in separate and independent raceway system.

H. Circuit wiring color-code, as established by installer, to be maintained throughout installation.

I. Size conductors in accordance with device manufacturer's recommendations. Increase AWG size of alarm conductors, if necessary, to maintain terminal voltage drop within acceptable level required by NEC and NFPA.

J. Detectors shall not be installed until after construction clean up of trades is complete, per requirements of NFPA. Exception, where required by AHJ for protection during construction, detectors installed prior to final clean-up by trades shall be cleaned or replaced.

K. Duct Smoke Detector: Furnish, wire, and connect to fire alarm system in accordance with this Specification. Installed in accordance with Section 23 09 13, HVAC Controls, Field Components, and Instruments.

L. HVAC Equipment: Wire and connect fire alarm system to air handling system, smoke damper control circuits, and fan status contacts. Coordinate work with Section 23 09 00, Instrumentation and Control Devices for HVAC.

M. Suppression Sprinkler System: Wire and connect to fire alarm system to suppression sprinkler system. Coordinate work with Section 21 13 00, Fire-Suppression Sprinkler Systems.

3.03 CONDUIT

A. Requirements apply to fire alarm system conduits, electrical enclosures, terminal cabinets, junction boxes, pullboxes, and device backboxes.

B. Conduit systems shall be dedicated to fire alarm system and shall contain no unrelated conductors.

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C. Fire alarm system conduits shall be of sizes and types specified under Section 26 05 33, Raceway and Boxes.

1. Conduit shall be as identified under Section 26 05 33, Raceway and Boxes. Flexible metallic conduit may be used for whips to devices only, maximum length 6 feet, 3/4-inch diameter minimum. Set screw type couplings or connectors are specifically prohibited.
2. Size conduits according to conductors contained therein. Cross sectional area percentage fill for fire alarm system conduits shall not exceed 40 percent.

D. Route and install conduit to minimize potential for physical damage, either mechanical or by fire, and so as not to interfere with existing building systems, facilities or equipment, and to facilitate service and minimize maintenance. Coordinate installation between different trades to avoid conflicts.

1. Conduit, except flexible conduit whips to devices, shall be solidly attached to building structural members or permanent walls. Conduit shall not be attached to existing conduit, ductwork, cable trays, other ceiling equipment, drop ceiling hangers/grids or partition walls, except where necessary to connect to initiating, evacuation signaling or auxiliary function devices.
2. Conduit shall be routed either parallel or perpendicular to building structural members.
3. Conduit shall be installed at a height so as not to obstruct any portion of a window, doorway cable tray, stairway or a passageway, and shall not interfere with operation of existing mechanical or electrical equipment.
4. Conduit, junction boxes, pull boxes, terminal cabinets, electrical enclosures and device backboxes shall be readily accessible for inspection, testing, service and maintenance.
5. Conduits shall be arranged to minimize the possibility of water in those conduits draining through control panels.
    a. Conduit, except nipples between control panels shall be arranged to enter control cabinets from below.
    b. Conduit shall be provided with three, 1/4-inch drain holes at horizontal low point beneath each control cabinet.
6. Bushings shall be provided at termination of conduit, prior to installation of wire.
7. Install junction boxes as necessary. Conductors shall be pulled through junction boxes, without splices.
8. Pullboxes shall be installed in each conduit at intervals not to exceed 100 feet. Pullboxes shall be 4-inch square, minimum.

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9. Device backboxes and junction boxes shall be sized to accommodate number of conductors contained. Extension rings or extension boxes are prohibited.
10. Junction boxes, pull boxes, terminal cabinets, device backboxes, and raceways shall be gasketed and weather-tight per requirements of Section 26 05 33, Raceway and Boxes.

E. Conduit, junction boxes, panels, electrical enclosures, relays and device backboxes shall be exposed in unfinished areas. Conduit and device backboxes shall be concealed in walls, ceiling spaces, electrical shafts or closets, in finished areas, except as noted on Drawings. Exposed conduit penetrations of walls shall be provided with escutcheon plates on either side of the wall.

F. Conduit penetrations of walls, floors and ceilings shall be sealed around conduit(s) in accordance with Section 07 92 00, Joint Sealants, restoring walls, floors and ceilings to their original condition, fire resistance and integrity.

G. Pull boxes, junction boxes, conduit bodies, and terminal cabinets shall be painted “fire engine red” prior to installation. Provide touch-up painting, of normally visible pull boxes, junction boxes, and terminal cabinets prior to final acceptance testing.

H. Conduit shall be grounded by approved ground clamps, and per NEC requirements.

I. Mount end-of-line resistors on terminal blocks.

J. Detection and alarm wire shall be installed in separate conduits. Outgoing and return conductors for each supervised circuit shall be routed in separately as required by NFPA 72. The minimum separation of outgoing and return conduits shall be 1 foot vertically and 4 feet horizontally.

3.04 IDENTIFICATION

A. Junction, terminal, and pulling box covers shall be painted red and identified with engraved labels by zone and circuit that it contains.

B. Detection and terminal devices shall have engraved alphanumeric identification that shall be keyed to posted operations and maintenance instructions.

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3.05 CONDUCTORS

A. Requirements apply to fire alarm system conductors, including all signaling line, initiating device, indicating appliance, releasing function, remote signaling, ac and dc power and grounding/shield drain circuits.

B. Conductors shall be:

1. New; wire that has scrapes, nicks, gouges or crushed insulation shall not be used.
2. Installed in conduit.
3. Continuous between devices and between devices and intermediary terminal cabinets.
4. Low voltage conductors shall be minimum size No. 14 AWG. Smaller conductors shall only be permitted where part of a manufacturer's specific communications cable, i.e. addressable system.
5. In accordance with requirements of NEC, Article 760 for nonpower limited service.

C. Splices in conductors are specifically prohibited.

D. Types:

1. Conductors, except ac power conductors and grounding conductors, shall be solid copper or bunch tinned (bonded) stranded copper.
2. Stranded copper conductors are acceptable for ac power conductors and grounding conductors only.

E. Terminations, including field connections to supervisory resistors, diodes, relays or other devices shall be to numbered terminals or terminal strips and readily accessible for inspection, service, testing and maintenance.

1. Terminations shall be within junction boxes, device backboxes, terminal cabinets, control panels or other suitable metal enclosures.
2. Terminals and terminal strips shall be suitable for the size and number of conductors connected to them.
3. Each conductor termination shall be uniquely numbered with durable plastic tags or uniquely identifiable by a combination of numbers and color codes. These conductor numbers shall be shown on Contractor's Record Drawings (floor plans and detailed wiring diagrams) in a manner allowing ready identification of conductor terminations.
4. Wire nuts are prohibited.
5. Where pigtail devices are factory provided with wires too short to be connected to terminal strips (i.e., solenoids), such connections shall be soldered and taped.

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F. Control Panel Wiring:

1. Fully dressed and bundled with nylon tie wraps at 3-inch intervals.
2. Bundled wiring shall be routed parallel to terminal strips within control panels, with individual conductors turned out at 90 degree angles to their associated terminal connections.
3. AC power conductors shall be bundled and routed separately from low voltage conductors. A minimum 2-inch separation shall be maintained between ac power conductors and low voltage conductors wherever possible.
4. Control cabinets shall be sized to accommodate the requirements of this Section.
5. Control panels shall not be used as raceways. Conductors that do not terminate within a control panel shall not be routed through that control panel.

G. Conductors shall be separated into the following categories:

1. Low voltage circuits that serve devices.
2. ac power circuits.

H. Each category of conductors shall be installed in physically separated, dedicated conduits, and shall not interface with one another, except at common associated control equipment. Conductors shall be further segregated as necessary to conform to fire alarm system manufacturer's recommendations and as necessary to prevent electrical crosstalk between conductors installed in common conduits.

I. Wiring shall be THHN or TFFN stranded. Use of multi-conductor twisted pair or similar wiring is not permitted.

J. Install as nonpower limited circuits in accordance with NFPA 72, and NEC, Article 760.

K. Conductors looped around terminals are prohibited.

L. Wire nut splices are prohibited.

M. T-tapping of circuits is prohibited.

N. Circuits shall be megger tested to voltage rating of their insulation before final terminations are made.

3.06 OVERVOLTAGE AND SURGE PROTECTION

A. Install TVSS for fire alarm control panel per manufacturer's requirements.

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3.07 REPAIR/RESTORATION

A. Touch up scratches, mars, and dents, incurred during shipment or installation of equipment.

B. If required because of extensive damage, as determined by Engineer, refinish entire assembly.

C. Keep covers on smoke detectors until areas have been thoroughly cleaned.

3.08 TESTS AND INSPECTION

A. In accordance with Section 01 91 14, Equipment Testing and Facility Startup, and NFPA 72.

B. Demonstrate entire system meets performance requirements specified in Article System Description.

C. Perform tests in presence of code-enforcement authorities, Owner or Owner's Representative.

D. Each smoke detector shall be individually field tested prior to installing device at its designated location to ensure reliability after shipment and storage conditions. A dated log indicating system address, type of device, sensitivity and initials of technician performing test, using test equipment specifically designed for that purpose, shall be prepared and kept for final acceptance documentation. After testing detection devices, base shall be labeled with system address, date, and initials of installing technician. Labeling shall not be visible after installation is complete.

E. Test wiring runs for continuity, short circuits, and grounds before system is energized. Resistance, current, and voltage readings shall be made as work progresses.

1. Systematic record shall be maintained of all readings using schedules or charts of tests and measurements. Areas shall be provided on logging form for readings, dates, and witnesses.
2. Notify Fire Marshal and Owner before start of any required tests. Correct items found at variance with Drawings or Specification during testing or inspection.
3. Deliver test reports to Fire Marshal and Owner as completed.

F. Prepare final as-built Sequence of Operations Matrix (See Supplement at End of Section) referencing each alarm input to every output function affected as a result of an alarm, trouble, or supervisory condition on that. In case of outputs programmed using more complex logic functions involving "any", "or",

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"not", "count", "time", and "timer" statements; complete output equation shall be referenced in matrix.

G. Prepare complete listing of device labels for alphanumeric annunciator displays and logging printers prior to acceptance test.

1. Test system wiring to demonstrate correct system response and correct subsequent system operation in event of:
   a. Open, shorted, and grounded intelligent analog signaling line circuit.
   b. Open, shorted, and grounded network signaling line circuit.
   c. Open, shorted, and grounded conventional initiating device circuits.
   d. Primary power or battery disconnected.
   e. Loss of data communications between system annunciators.
2. Demonstrate system evacuation alarm indicating appliances as follows:
   a. Alarm notification appliances actuate as programmed.
   b. Audibility and visibility at required levels.
3. System indications shall be demonstrated as follows:
   a. Correct message display for each alarm input, at control panel, each remote alphanumeric LCD display.
   b. Correct annunciator light for each alarm input, at each annunciator and color graphic terminal.
4. Demonstrate system onsite and offsite reporting functions as follows:
   a. Correct alarm custom message display, address, device type, date and time transmitted, for each alarm input.
   b. Correct trouble custom message display, address, device type, date and time transmitted, for each alarm input.
   c. Trouble signals received for disconnect.
5. Secondary power capabilities shall be demonstrated as follows:
   a. Disconnect system primary power for a period of time as specified herein; at end of period, alarm condition shall be created and system shall perform as specified for period as specified.
   b. Restore system primary power for 48 hours and system-charging current shall be normal trickle charge for fully charged battery bank.
   c. Check system battery voltages and charging currents at fire alarm control panel using test codes and LCD displays.

H. In the event system fails to perform as specified and programmed during acceptance test, test shall be terminated at discretion of acceptance inspector.

1. Retest system, correcting deficiencies and providing test documentation to acceptance inspector.
2. In event that software changes are required during acceptance test, system manufacturer to compare edited program with original and shall

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furnish utility program. Utility shall yield printed list of changes and system functions, inputs and outputs affected by changes. Items listed by program shall be minimum acceptable to be retested before calling for resumption of acceptance test. Submit printed list and printer log of retesting before scheduling of acceptance test.

3. Acceptance inspector may elect to require complete acceptance test to be performed again if, in their opinion, modifications to system hardware or software warrant complete retesting.

I. Upon completion of tests, complete and provide the following:

1. NFPA 72, Record of Completion, and Inspection and Testing Form.
2. Certification that final system meets UL.

3.09 MANUFACTURER'S SERVICES

A. Furnish manufacturer's representative **[A: in accordance with Section 01 43 33, Manufacturers' Field Services,]** for the following services at site or classroom as designated by Owner, for minimum person-days listed below, travel time excluded:

1. 2 person-days for installation assistance and inspection.
2. 2 person-days for performance testing.
3. 1 person-day for prestartup classroom or site training.

3.10 SUPPLEMENTS

A. The supplement listed below, following "End of Section," is a part of this Specification.

1. Sequence of Operations Matrix.

END OF SECTION

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SEQUENCE OF OPERATIONS MATRIX

SYSTEM OUTPUTS

	FACP ANNUNCIATION											NOTIFICATION											FIRE SAFETY			
SYSTEM INPUTS	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
1																										
2																										
3																										
4																										
5																										
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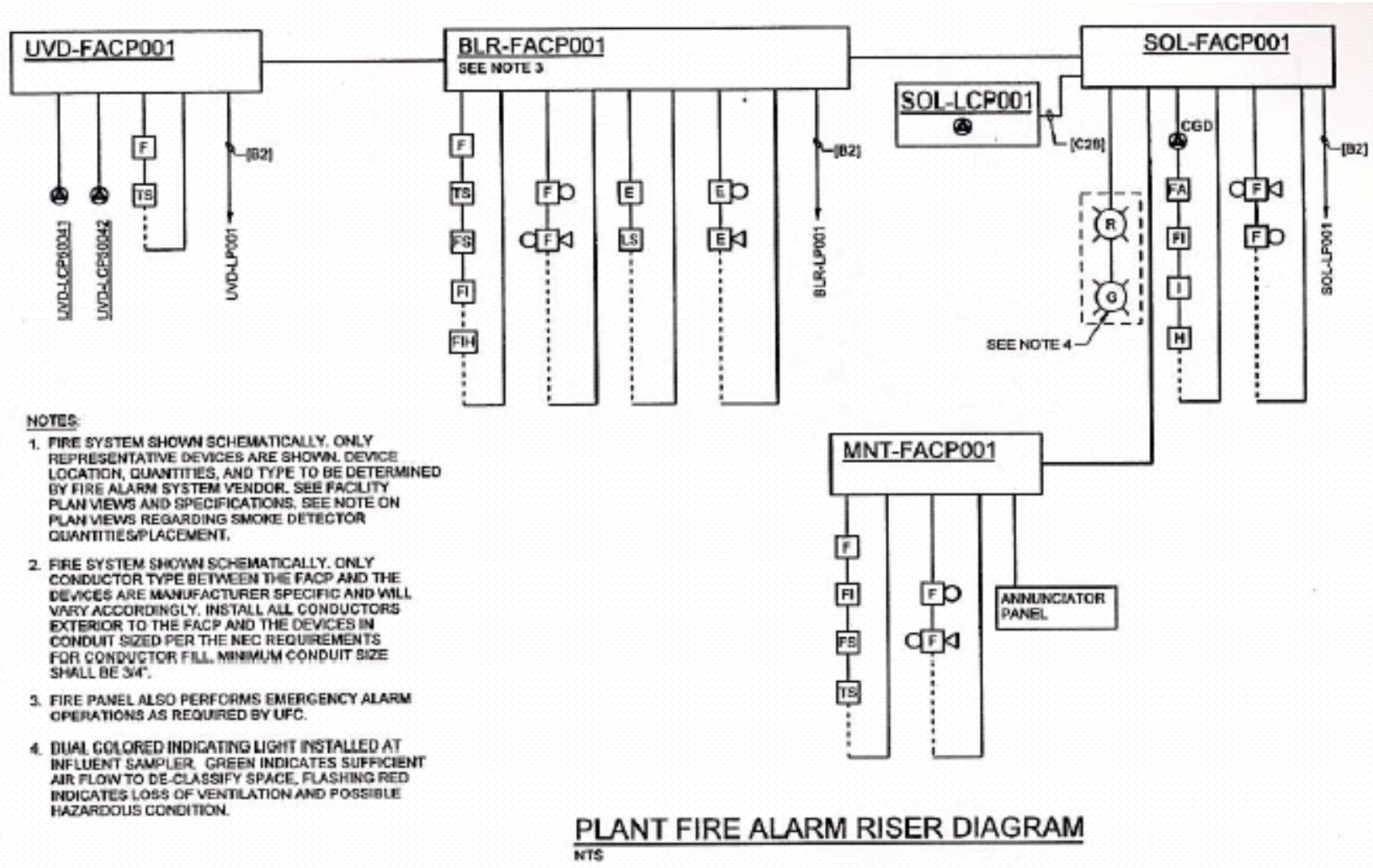

NOTES:

1. FIRE SYSTEM SHOWN SCHEMATICALLY. ONLY REPRESENTATIVE DEVICES ARE SHOWN. DEVICE LOCATION, QUANTITIES, AND TYPE TO BE DETERMINED BY FIRE ALARM SYSTEM VENDOR. SEE FACILITY PLAN VIEWS AND SPECIFICATIONS. SEE NOTE ON PLAN VIEWS REGARDING SMOKE DETECTOR QUANTITIES/PLACEMENT.
2. FIRE SYSTEM SHOWN SCHEMATICALLY. ONLY CONDUCTOR TYPE BETWEEN THE FACP AND THE DEVICES ARE MANUFACTURER SPECIFIC AND WILL VARY ACCORDINGLY. INSTALL ALL CONDUCTORS EXTERIOR TO THE FACP AND THE DEVICES IN CONDUIT SIZED PER THE NEC REQUIREMENTS FOR CONDUCTOR FILL. MINIMUM CONDUIT SIZE SHALL BE 3/4".
3. FIRE PANEL ALSO PERFORMS EMERGENCY ALARM OPERATIONS AS REQUIRED BY UFC.
4. DUAL COLORED INDICATING LIGHT INSTALLED AT INFLUENT SAMPLER. GREEN INDICATES SUFFICIENT AIR FLOW TO DE-CLASSIFY SPACE. FLASHING RED INDICATES LOSS OF VENTILATION AND POSSIBLE HAZARDOUS CONDITION.

PLANT FIRE ALARM RISER DIAGRAM

NTS

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SEQUENCE OF OPERATIONS

FACP00X FIRE AND EMERGENCY ALARM SYSTEM

SYSTEM OUTPUTS

SYSTEM INPUTS	FACP ANNUNCIATION							NOTIFICATION					
	A ACTUATE COMMON ALARM INDICATOR	B ACTUATE AUDIBLE ALARM SIGNAL	C ACTUATE COMMON SUPV SIGNAL INDIC.	D ACTUATE AUDIBLE SUPERVISORY SIGNAL	E ACTUATE COMMON TROUBLE SIGNAL INDIC.	F ACTUATE AUDIBLE COMMON TROUBLE SIGNAL	G TEXT DISPLAY OF DEVICE LOCATION AND DESCRIPTION	H ACTUATE BLDG EVACUATION SIGNAL	I ACTUATE BLDG EMERGENCY EVACUATION SIGNAL	J TRANSMIT DESCRIPTION OF FIRE ALARM SIGNAL TO FACP001	K TRANSMIT DESCRIPTION OF SUPERVISORY SIGNAL TO FACP001	L TRANSMIT DESCRIPTION OF TROUBLE SIGNAL TO FACP001	M TRANSMIT DESCRIPTION OF EMERGENCY ALARM TO FACP001
1 MANUAL PULL STATION	X	X					X	X		X			
2 SMOKE DET ELECTRICAL ROOM	X	X					X	X		X			
3 SMOKE DETECTOR CHEMICAL STORAGE	X	X					X	X		X			
4 WATERFLOW SWITCH	X	X					X	X		X			
5 SPRINKLER CONTROL VALVE			X	X			X				X		
6 EMERGENCY MANUAL PULL STATION		X					X		X				X
7 CHEMICAL CONTAINMENT FLOAT (LS)		X					X		X				X
8 FACP AC POWER FAILURE			X	X							X		
9 FACP SYSTEM SILENCE			X								X		
10 FACP SYSTEM LOW BATTERY					X	X						X	
11 OPEN CIRCUIT					X	X						X	
12 GROUND FAULT					X	X						X	
13 NOTIFICATION APPLIANCE SHORT CIRCUIT					X	X						X	

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SECTION 31 10 00
SITE CLEARING

PART 1 GENERAL

1.01 DEFINITIONS

A. Interfering or Objectionable Material: Trash, rubbish, and junk; vegetation and other organic matter, whether alive, dead, or decaying; topsoil.

B. Clearing: Removal of interfering or objectionable material lying on or protruding above ground surface.

C. Grubbing: Removal of vegetation and other organic matter including stumps, buried logs, and roots greater than 2-inch caliper to a depth of 6 inches below subgrade.

D. Stripping: Removal of topsoil remaining after applicable grubbing is complete.

E. Project Limits: Areas, as shown or specified, within which Work is to be performed.

1.02 SCHEDULING AND SEQUENCING

A. Prepare Site only after adequate erosion and sediment controls are in place. Limit areas exposed uncontrolled to erosion during installation of temporary erosion and sediment controls to maximum of 0.25 acres.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 GENERAL

A. Clear, grub, and strip areas actually needed for waste disposal, borrow, or Site improvements within limits shown or specified.

B. Do not injure or deface vegetation that is not designated for removal.

3.02 LIMITS

A. As follows, but not to extend beyond Project limits.

1. Excavation Excluding Trenches: 5 feet beyond top of cut slopes.

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2. Fill:
    a. Clearing and Grubbing: 5 feet beyond toe of permanent fill.
    b. Stripping: 2 feet beyond toe of permanent fill.
3. Waste Disposal:
    a. Clearing: 5 feet beyond perimeter.
    b. Stripping: Not required.
    c. Grubbing: Around perimeter as necessary for neat finished appearance.
4. Structures: 15 feet outside of new structures.
5. Roadways: Clearing and grubbing, and stripping 15 feet from roadway shoulders.
6. Overhead Utilities:
    a. Clearing and Grubbing: Entire width of easements and rights-of-way.
    b. Stripping: Wherever grading is required.
7. Other Areas: As shown.

B. Remove rubbish, trash, and junk from entire area within Project limits.

3.03 CLEARING

A. Clear areas within limits shown or specified.

B. Fell trees so that they fall away from facilities and vegetation not designated for removal.

C. Cut stumps not designated for grubbing flush with ground surface.

D. Cut off shrubs, brush, weeds, and grasses to within 2 inches of ground surface.

3.04 GRUBBING

A. Grub areas within limits shown or specified.

3.05 STRIPPING

A. Do not remove topsoil until after grubbing is completed.

B. Strip areas within limits to minimum depths shown or specified. Do not remove subsoil with topsoil.

C. Stockpile strippings separately from other excavated material.

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3.06 DISPOSAL

A. Clearing and Grubbing Debris:

1. Dispose of debris offsite at appropriately permitted disposal facilities.
2. Limit offsite disposal of clearing and grubbing debris to locations that are approved by federal, state, and local authorities, and that will not be visible from Project.

B. Strippings:

1. Dispose of strippings that are unsuitable for topsoil or that exceed quantity required as specified for clearing and grubbing debris.
2. Stockpile topsoil in sufficient quantity to meet Project needs. Dispose of excess strippings as specified for clearing and grubbing.

END OF SECTION

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SECTION 31 23 13
SUBGRADE PREPARATION

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM): D1557, Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3 (2,700 kN-m/m^3)).

1.02 DEFINITIONS

A. Optimum Moisture Content: As defined in Section 31 23 23, Fill and Backfill.

B. Prepared Ground Surface: Ground surface after completion of clearing and grubbing, scalping of sod, stripping of topsoil, excavation to grade, and scarification and compaction of subgrade.

C. Relative Compaction: As defined in Section 31 23 23, Fill and Backfill.

D. Relative Density: As defined in Section 31 23 23, Fill and Backfill.

E. Subgrade: Layer of existing soil after completion of clearing, grubbing, scalping of topsoil prior to placement of fill, roadway structure or base for floor slab.

F. Proof-Rolling: Testing of subgrade by compactive effort to identify areas that will not support the future loading without excessive settlement.

1.03 SEQUENCING AND SCHEDULING

A. Complete applicable Work specified in Section 31 10 00, Site Clearing and Section 31 23 16, Excavation, prior to subgrade preparation.

1.04 QUALITY ASSURANCE

A. Notify Contractor when subgrade is ready for compaction or proof-rolling or whenever compaction or proof-rolling is resumed after a period of extended inactivity.

1.05 ENVIRONMENTAL REQUIREMENTS

A. Prepare subgrade when unfrozen and free of ice and snow.

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PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 GENERAL

A. Keep subgrade free of water, debris, and foreign matter during compaction or proof-rolling.

B. Bring subgrade to proper grade and cross-section and uniformly compact surface.

C. Do not use sections of prepared ground surface as haul roads. Protect prepared subgrade from traffic.

D. Maintain prepared ground surface in finished condition until next course is placed.

3.02 PROOF-ROLLING

A. Subgrades under structures, footings, slabs and fill under structures shall be proof-rolled prior to structure, concrete or fill placement using a 10-ton (minimum) vibratory roller operating at 1,100 to 1,500 vibrations per minute.

B. Proof-rolling of subgrades for pavements shall be accomplished with a heavily loaded vehicle. The vehicle must have a loaded gross vehicle weight (GVW) of 50,000 pounds with a loaded single axle weight of at least 18,000 pounds and a minimum tire pressure of 90 pounds per square inch (psi).

C. Any loose, soft, or yielding areas identified by proof-rolling shall be compacted in place or removed and replaced with granular fill.

D. Subgrades that cannot be proof-rolled shall be probed and observed Professional Observation as specified in Section 01 45 33, Special Inspection and Testing.

3.03 COMPACTION

A. Under Earthfill: Compact upper 6 inches to minimum of 90 percent relative compaction as determined in accordance with ASTM D1557.

B. Under Pavement Structure, Floor Slabs On Grade, or Granular Fill Under Structures: Compact the upper 6 inches to minimum of 95 percent relative compaction as determined in accordance with ASTM D1557.

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3.04 MOISTURE CONDITIONING

A. Dry Subgrade: Add water, then mix to make moisture content uniform throughout.

B. Wet Subgrade: Aerate material by blading, discing, harrowing, or other methods, to hasten drying process.

3.05 TESTING

A. Proof-roll subgrade to detect soft or loose subgrade or unsuitable material, as determined by Contractor.

3.06 CORRECTION

A. Soft or Loose Subgrade:

1. Adjust moisture content and recompact, or
2. Over excavate as specified in Section 31 23 16, Excavation, and replace with suitable material from the excavation, as specified in Section 31 23 23, Fill and Backfill.

B. Unsuitable Material: Over excavate as specified in Section 31 23 16, Excavation, and replace with suitable material from the excavation, as specified in Section 31 23 23, Fill and Backfill.

END OF SECTION

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SECTION 31 23 16
EXCAVATION

PART 1 GENERAL

1.01 SUBMITTALS

A. Informational Submittals:

1. Excavation Plan, Detailing:
   a. Methods and sequencing of excavation.
   b. Proposed locations of stockpiled excavated material.
   c. Proposed onsite and offsite spoil disposal sites.
   d. Numbers, types, and sizes of equipment proposed to perform excavations.

1.02 QUALITY ASSURANCE

A. Provide adequate survey control to avoid unauthorized overexcavation.

1.03 WEATHER LIMITATIONS

A. Material excavated when frozen or when air temperature is less than 32 degrees F shall not be used as fill or backfill until material completely thaws.

B. Material excavated during inclement weather shall not be used as fill or backfill until after material drains and dries sufficiently for proper compaction.

1.04 SEQUENCING AND SCHEDULING

A. Clearing, Grubbing, and Stripping: Complete applicable Work specified in Section 31 10 00, Site Clearing, prior to excavating.

B. Excavation Support: Install and maintain as necessary to support sides of excavations and prevent detrimental settlement and lateral movement of adjacent property and completed Work.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 GENERAL

A. Excavate to lines, grades, and dimensions shown and as necessary to accomplish Work. Excavate to within tolerance of plus or minus 0.1 foot,

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except where dimensions or grades are shown or specified as maximum or minimum. Allow for forms, working space, granular base, topsoil, and similar items, wherever applicable. Trim to neat lines where concrete is to be deposited against earth.

B. Do not overexcavate without written authorization of Contractor.

C. Remove or protect obstructions as shown on the Drawings and as specified in Section 01 50 00, Temporary Facilities and Controls, Article Protection of Work and Property.

3.02 UNCLASSIFIED EXCAVATION

A. Excavation is unclassified. Complete all excavation regardless of the type, nature, or condition of the materials encountered.

3.03 TRENCH WIDTH

A. Minimum Width of Trenches:

1. Single Pipes, Conduits, Direct-Buried Cables, and Duct Banks:
   a. Less than 4-inch Outside Diameter or Width: 24 inches.
   b. Greater than 4-inch Outside Diameter or Width: 24 inches greater than outside diameter or width of pipe, conduit, direct-buried cable, or duct bank.
2. Multiple Pipes, Conduits, Cables, or Duct Banks in Single Trench: 24 inches greater than aggregate width of pipes, conduits, cables, duct banks, plus space between.
3. Increase trench widths by thicknesses of sheeting.

B. Maximum Trench Width: Unlimited, unless otherwise shown or specified, or unless excess width will cause damage to existing facilities, adjacent property, or completed Work. Pipe of greater strength or superior pipe bedding, when approved in writing by Contractor, may be used in lieu of maintaining the pipe widths shown or specified.

3.04 PIPE BEDDING GROOVES FOR NONPERFORATED DRAIN LINES

A. Semicircular, trapezoidal, or 90-degree-V.

B. Excavated or plowed into trench bottom. Forming groove by compaction will not be acceptable.

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3.05 EMBANKMENT AND CUT SLOPES

A. Shape, trim, and finish cut slopes to conform with lines, grades, and cross-sections shown, with proper allowance for topsoil or slope protection, where shown.

B. Remove stones and rock that exceed 3-inch diameter and that are loose and may roll down slope. Remove exposed roots from cut slopes.

C. Round tops of cut slopes in soil to not less than a 6-foot radius, provided such rounding does not extend offsite or outside easements and rights-of-way, or adversely impacts existing facilities, adjacent property, or completed Work.

3.06 STOCKPILING EXCAVATED MATERIAL

A. Stockpile excavated material that is suitable for use as fill or backfill until material is needed.

B. Post signs indicating proposed use of material stockpiled. Post signs that are readable from all directions of approach to each stockpile. Signs should be clearly worded and readable by equipment operators from their normal seated position.

C. Confine stockpiles to within easements, rights-of-way, and approved work areas. Do not obstruct roads or streets.

D. Do not stockpile excavated material adjacent to trenches and other excavations, unless excavation side slopes and excavation support systems are designed, constructed, and maintained for stockpile loads.

E. Do not stockpile excavated materials near or over existing facilities, adjacent property, or completed Work, if weight of stockpiled material could induce excessive settlement.

3.07 DISPOSAL OF SPOIL

A. Dispose of excavated materials, which are unsuitable or not needed for fill or backfill, in designated spoil disposal areas.

B. Dispose of debris resulting from removal of objectionable material as specified in Section 31 10 00, Site Clearing, for clearing and grubbing debris.

END OF SECTION

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SECTION 31 23 23
FILL AND BACKFILL

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   a. C117, Standard Test Method for Materials Finer Than 75-Micrometers (No. 200) Sieve in Mineral Aggregates by Washing.
   b. C136, Standard Method for Sieve Analysis of Fine and Coarse Aggregates.
   c. D75, Standard Practice for Sampling Aggregates.
   d. D1556, Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method.
   e. D1557, Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3 (2,700 kN-m/m^3)).
   f. D4253, Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table.
   g. D4254, Standard Test Method for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density.
   h. D6938, Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

1.02 DEFINITIONS

A. Relative Compaction:

1. Ratio, in percent, of as-compacted field dry density to laboratory maximum dry density as determined in accordance with ASTM D1557.
2. Apply corrections for oversize material to either as-compacted field dry density or maximum dry density, as determined by Contractor.

B. Optimum Moisture Content:

1. Determined in accordance with ASTM Standard specified to determine maximum dry density for relative compaction.
2. Determine field moisture content on basis of fraction passing 3/4-inch sieve.

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C. Relative Density: Calculated in accordance with ASTM D4254 based on maximum index density determined in accordance with ASTM D4253 and minimum index density determined in accordance with ASTM D4254.

D. Prepared Ground Surface: Ground surface after completion of required demolition, clearing and grubbing, scalping of sod, stripping of topsoil, excavation to grade, and subgrade preparation.

E. Completed Course: A course or layer that is ready for next layer or next phase of Work.

F. Lift: Loose (uncompacted) layer of material.

G. Geosynthetics: Geotextiles, geogrids, or geomembranes.

1. Influence Area: Area within planes sloped downward and outward at 60-degree angle from horizontal measured from:
2. 1 foot outside outermost edge at base of foundations or slabs.
3. 1 foot outside outermost edge at surface of roadways or shoulder.
4. 0.5 foot outside exterior at spring line of pipes or culverts.

H. Borrow Material: Material from required excavations or from designated borrow areas on or near Site.

I. Selected Backfill Material: Materials available onsite that Contractor determines to be suitable for specific use.

J. Imported Material: Materials obtained from sources offsite, suitable for specified use.

K. Structural Fill: Fill materials as required under structures, pavements, and other facilities.

L. Embankment Material: Fill materials required to raise existing grade in areas other than under structures.

M. Standard Specifications: When referenced in this section, shall mean New Mexico Standard Specifications for Public Works Construction.

1.03 QUALITY ASSURANCE

A. Notify Contractor when:

1. Structure or tank is ready for backfilling, and whenever backfilling operations are resumed after a period of inactivity.
2. Soft or loose subgrade materials are encountered wherever embankment or site fill is to be placed.
3. Fill material appears to be deviating from Specifications.

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1.04 SEQUENCING AND SCHEDULING

A. Complete applicable Work specified in Section 31 10 00, Site Clearing; Section 31 23 16, Excavation; and Section 31 23 13, Subgrade Preparation, prior to placing fill or backfill.

B. Backfill against concrete structures only after concrete has attained compressive strength, specified in Section 03 30 00, Cast-in-Place Concrete. Obtain Contractor's acceptance of concrete work and attained strength prior to placing backfill.

C. Backfill around water-holding structures only after completion of satisfactory leakage tests as specified in Section 03 30 00, Cast-in-Place Concrete.

D. Backfill around buried tanks only after tank is set in position, securely anchored, and ready to be backfilled, and Contractor provides authorization to backfill.

E. Do not place granular base, subbase, or surfacing until after subgrade has been prepared as specified in Section 31 23 13, Subgrade Preparation.

PART 2 PRODUCTS

2.01 EARTHFILL

A. Excavated material from required excavations and designated borrow sites, free from rocks larger than 3 inches, from roots and other organic matter, ashes, cinders, trash, debris, and other deleterious materials.

B. Material containing more than 10 percent gravel, stones, or shale particles is unacceptable.

C. Provide imported material of equivalent quality, if required to accomplish Work.

2.02 STRUCTURAL FILL

A. On site soils meeting the following criteria shall be used for structural fill:

Sieve Size	Percent Passing by Weight
3-inch	100
No. 4	50 - 100
No. 200	10 - 50

B. Fill materials shall be free from roots, grass, other organic material, clay lumps and other deleterious material.

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2.03 SAND

A. Free from clay, organic matter, or other deleterious material.

B. Gradation as determined in accordance with ASTM C117 and ASTM C136:

Sieve Size	Percent Passing by Weight
1/4-inch	100
No. 4	95 - 100
No. 200	0 - 8

2.04 GRANULAR DRAIN MATERIAL

A. As specified in Section 31 23 23.15, Trench Backfill.

2.05 WATER FOR MOISTURE CONDITIONING

A. Free of hazardous or toxic contaminates, or contaminants deleterious to proper compaction.

2.06 BASE COURSE ROCK

A. As specified in Section 32 11 23, Aggregate Base Courses.

2.07 FOUNDATION STABILIZATION ROCK

A. Crushed rock or pit run rock.

B. Uniformly graded from coarse to fine.

C. Free from excessive dirt and other organic material.

D. Maximum 2-1/2-inch particle size.

2.08 SOIL COVER OVER GEOTEXTILES

A. Particle Size: Maximum 1 inch.

B. Free of sharp angular pieces that may damage geotextile.

2.09 SOIL COVER OVER GEOMEMBRANES

A. Granular material.

B. Particle Size: Maximum 1/4 inch.

C. Particle Shape: Rounded.

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PART 3 EXECUTION

3.01 GENERAL

A. Keep placement surfaces free of water, debris, and foreign material during placement and compaction of fill and backfill materials.

B. Place and spread fill and backfill materials in horizontal lifts of uniform thickness, in a manner that avoids segregation, and compact each lift to specified densities prior to placing succeeding lifts. Slope lifts only where necessary to conform to final grades or as necessary to keep placement surfaces drained of water.

C. During filling and backfilling, keep level of fill and backfill around each structure and buried tank even.

D. Do not place fill or backfill, if fill or backfill material is frozen, or if surface upon which fill or backfill is to be placed is frozen.

E. If pipe, conduit, duct bank, or cable is to be laid within fill or backfill:

1. Fill or backfill to an elevation 2 feet above top of item to be laid.
2. Excavate trench for installation of item.
3. Install bedding, if applicable, as specified in Section 31 23 23.15, Trench Backfill.
4. Install item.
5. Backfill envelope zone and remaining trench, as specified in Section 31 23 23.15, Trench Backfill, before resuming filling or backfilling specified in this section.

F. Tolerances:

1. Final Lines and Grades: Within a tolerance of 0.1 foot unless dimensions or grades are shown or specified otherwise.
2. Grade to establish and maintain slopes and drainage as shown. Reverse slopes are not permitted.

G. Settlement: Correct and repair any subsequent damage to structures, pavements, curbs, slabs, piping, and other facilities, caused by settlement of fill or backfill material.

3.02 BACKFILL UNDER AND AROUND STRUCTURES

A. Under Facilities: Within influence area beneath structures, slabs, pavements, curbs, conduits, duct banks, and other facilities, backfill with structural fill, unless otherwise shown. Place structural fill in lifts of 6 inch maximum thickness and compact each lift to minimum of 95 percent relative compaction

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as determined in accordance with ASTM D1557 Method Maximum Standard Proctor Density. Pipeline: As specified in Section 31 23 23.15, Trench Backfill.

B. Subsurface Drainage: Backfill with granular drain material, where shown. Place granular drain material in lifts of 6 inch maximum thickness and compact each lift to minimum of 95 percent relative density.

C. Other Areas: Backfill with earthfill to lines and grades shown, with proper allowance for topsoil thickness where shown. Place in lifts of 6 inch maximum thickness and compact each lift to minimum 90 percent relative compaction as determined in accordance with ASTM D1557, Method Maximum Standard Proctor Density.

3.03 FILL

A. Outside Influence Areas beneath Structures, Tanks, Pavements, Curbs, Slabs, Piping, and Other Facilities: Unless otherwise shown, place earthfill as follows:

1. Allow for 6-inch thickness of topsoil where required.
2. Maximum 8-inch thick lifts.
3. Place and compact fill across full width of embankment.
4. Compact fill to 90 percent relative compaction as determined by ASTM D1557.
5. Dress completed embankment with allowance for topsoil, crest surfacing, and slope protection, where applicable.

3.04 SITE TESTING

A. Gradation:

1. One sample from each 1,500 tons of finished product or more often as determined by Contractor, if variation in gradation is occurring, or if material appears to depart from Specifications.
2. If test results indicate material does not meet Specification requirements, terminate material placement until corrective measures are taken.
3. Remove material placed in Work that does not meet Specification requirements.

B. In-Place Density Tests: In accordance with ASTM D1556 or a combination of ASTM D1556 and ASTM D6938. If ASTM D6938 is used to test in-place density, verify test results by performing at least one test per day using ASTM D1556 at location already tested in accordance with ASTM D6938. Perform at least one additional test using ASTM D1556 for every ten tests

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performed with a nuclear device, at locations checked in accordance with ASTM D6938. During placement of materials, test as follows:

1. Structural Fill: Test every 500 cubic yards, but no less than one test per location.
2. Sand: Test every 500 cubic yards, but no less than one test per location.
3. Backfill Around Buried Tanks: Test every 200 cubic yards, but no less than one test per location.
4. Granular Drain Material: Test every 500 cubic yards, but no less than one test per location.
5. Granular Filter Material: Test every 500 cubic yards, but no less than one test per location.
6. Base Course Rock: Test every 500 cubic yards, but no less than one test per location.
7. Foundation Stabilization Rock: Test every 500 cubic yards, but no less than one test per location.
8. Crushed Rock for Substations:
    a. Base Course: Test every 500 cubic yards, but no less than one test per location.
    b. Finish Grade Rock: Test every 500 cubic yards, but no less than one test per location.
    c. Access Road Surfacing: Test every 500 cubic yards, but no less than one test per location.
9. Soil Cover Over Geotextiles: Test every 500 cubic yards, but no less than one test per location.
10. Soil Cover Over Geomembranes: Test every 500 cubic yards, but no less than one test per location.

3.05 GRANULAR BASE, SUBBASE, AND SURFACING

A. Place and Compact as specified in Section 32 11 23, Aggregate Base Courses.

3.06 REPLACING OVEREXCAVATED MATERIAL

A. Replace excavation carried below grade lines shown or established by Contractor as follows:

1. Beneath Footings: As specified in Section 03 30 00, Cast-in-Place Concrete.
2. Beneath Fill or Backfill: Same material as specified for overlying fill or backfill.
3. Beneath Slabs-On-Grade: Structural fill.
4. Trenches:
    a. Unauthorized Overexcavation: Either trench stabilization material or granular pipe base material, as specified in Section 31 23 23.15, Trench Backfill.

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b. Authorized Overexcavation: Trench stabilization material, as specified in Section 31 23 23.15, Trench Backfill.

5. Permanent Cut Slopes (Where Overlying Area is Not to Receive Fill or Backfill):
   a. Flat to Moderate Steep Slopes (3:1, Horizontal Run: Vertical Rise or Flatter): Earthfill.
   b. Steep Slopes (Steeper than 3:1):
      1) Correct overexcavation by transitioning between overcut areas and designed slope adjoining areas, provided such cutting does not extend offsite or outside easements and right-of-way's, or adversely impacts existing facilities, adjacent property, or completed Work.
      2) Backfilling overexcavated areas is prohibited, unless in Contractor's opinion, backfill will remain stable, and overexcavated material is replaced as compacted earthfill.

3.07 ACCESS ROAD SURFACING

A. Place and compact as specified in Section 32 11 23, Aggregate Base Courses.

END OF SECTION

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SECTION 31 23 23.15
TRENCH BACKFILL

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Public Works Association (APWA): Uniform Color Code.
2. ASTM International (ASTM):
   a. [SL1][SL2][SL3]C136, Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
   b. [SL4][SL5][SL6]D1140, Standard Test Methods for Amount of Material in Soils Finer than No. 200 (75 micrometer) Sieve.
   c. D1557, Standard Test Methods for Laboratory Compaction Characteristics of Soil using Modified Effort (56,000 ft-lbf/ft^3 (2,700 kN-m/m^3)).
   d. D2487, Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System).
   e. D4253, Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table.
   f. D4254, Standard Test Methods for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density.
   g. D4318, Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.
   h. D4832, Standard Test Method for Preparation and Testing of Controlled Low Strength Material (CLSM) Test Cylinders.
3. National Electrical Manufacturers Association (NEMA): Z535.1, Safety Colors.

1.02 DEFINITIONS

A. Base Rock: Granular material upon which manhole bases and other structures are placed.

B. Bedding Material: Granular material upon which pipes, conduits, cables, or duct banks are placed.

C. Imported Material: Material obtained by Contractor from source(s) offsite.

D. Lift: Loose (uncompacted) layer of material.

E. Pipe Zone: Backfill zone that includes full trench width and extends from prepared trench bottom to an upper limit above top outside surface of pipe, conduit, cable or duct bank.

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F. Prepared Trench Bottom: Graded trench bottom after excavation and installation of stabilization material, if required, but before installation of bedding material.

G. Relative Compaction: Refer to Section 31 23 23, Fill and Backfill.

H. Relative Density: As defined by ASTM D4253 and ASTM D4254.

I. Selected Backfill Material: Material available onsite that Contractor determines to be suitable for a specific use.

J. Well-Graded: A mixture of particle sizes that has no specific concentration or lack thereof of one or more sizes producing a material type that, when compacted, produces a strong and relatively incompressible soil mass free from detrimental voids. Satisfying both of the following requirements, as defined in ASTM D2487:

1. Coefficient of Curvature: Greater than or equal to 1 and less than or equal to 3.
2. Coefficient of Uniformity: Greater than or equal to 4 for materials classified as gravel, and greater than or equal to 6 for materials classified as sand.

1.03 SUBMITTALS

A. Informational Submittals:

1. Certified Gradation Analysis: Submit not less than 30 days prior to delivery for imported materials or anticipated use for excavated materials, except for trench stabilization material that will be submitted prior to material delivery to Site.

[SL7]PART 2 PRODUCTS

2.01 GEOTEXTILE

A. As specified in Section 31 32 19.16, Geotextile.

2.02 MARKING TAPE

A. Detectable:

1. Solid aluminum foil, visible on unprinted side, encased in protective high visibility, inert polyethylene plastic jacket.
2. Foil Thickness: Minimum 0.35 mils.
3. Laminate Thickness: Minimum 7 mils.
4. Width: 6 inches.

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5. Identifying Lettering: Minimum 1-inch high, permanent black lettering imprinted continuously over entire length.
6. Joining Clips: Tin or nickel-coated furnished by tape manufacturer.
7. Manufacturers and Products:
    a. Reef Industries; Terra Tape, Sentry Line Detectable.
    b. Mutual Industries; Detectable Tape.
    c. Presco; Detectable Tape.

B. Color: In accordance with APWA Uniform Color Code.

Color*	Facility
Red	Electric power lines, cables, conduit, and lightning cables
Orange	Communicating alarm or signal lines, cables, or conduit
Yellow	Gas, oil, steam, petroleum, or gaseous materials
Green	Sewers and drain lines
Blue	Potable water
Purple	Reclaimed water, irrigation, and slurry lines
*As specified in NEMA Z535.1, Safety Color Code.	

2.03 TRENCH STABILIZATION MATERIAL

A. Base Rock:

1. Clean, hard, durable 3-inch minus crushed rock or gravel, or pit run, free from clay balls, other organic materials, or debris.
2. Uniformly graded from coarse to fine, less than 8 percent by weight passing the 1/4-inch sieve.

2.04 BEDDING MATERIAL AND PIPE ZONE MATERIAL

A. Unfrozen, friable, and no clay balls, roots, or other organic material.

B. Clean or gravelly sand with less than 5 percent passing No. 200 sieve, as determined in accordance with ASTM D1140, or gravel or crushed rock within maximum particle size and other requirements as follows unless otherwise specified.

1. Duct Banks: 3/4-inch maximum particle size.
2. Pipe Under 18-Inch Diameter: 3/4-inch maximum particle size, except 1/4 inch for stainless steel pipe, copper pipe, tubing, and plastic pipe under 3-inch diameter.

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3. Pipe 18-Inch Diameter and Greater: 1-1/2-inch maximum particle size for ductile iron pipe, concrete pipe, welded steel pipe, and pretensioned or prestressed concrete cylinder pipe.
4. Perforated Pipe: Granular drain material.
5. Conduit and Direct-Buried Cable:
    a. Sand, clean or clean to silty, less than 12 percent passing No. 200 sieve.
    b. Individual Particles: Free of sharp edges.
    c. Maximum Size Particle: Pass a No. 4 sieve.
    d. If more than 5 percent passes No. 200 sieve, the fraction that passes No. 40 sieve shall be nonplastic as determined in accordance with ASTM D4318.

2.05 GRANULAR DRAIN MATERIAL

A. Well graded with a maximum particle size of 3 inches and no more than 6 percent fines.

2.06 EARTHFILL

A. As specified in Section 31 23 23, Fill and Backfill.

2.07 PROCESSED EARTH

A. Earth backfill, meeting the following additional requirement.

1. Free of boulders and cobbles that would be retained on 6-inch screen, and portion retained on 3/4-inch sieve to less than 30 percent.

2.08 CONCRETE BACKFILL

A. Provide as specified in Section 03 30 00, Cast-in-Place Concrete.

2.09 GRAVEL SURFACING ROCK

A. As specified in Section 32 11 23, Aggregate Base Courses.

2.10 SOURCE QUALITY CONTROL

A. Perform gradation analysis in accordance with ASTM C136 for:

1. Earth backfill, including specified class.
2. Trench stabilization material.
3. Bedding and pipe zone material.
4. Certify Laboratory Performance of Mix Designs.

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PART 3 EXECUTION

3.01 TRENCH PREPARATION

A. Water Control:

1. Promptly remove and dispose of water entering trench as necessary to grade trench bottom and to compact backfill and install manholes, pipe, conduit, direct-buried cable, or duct bank. Do not place concrete, lay pipe, conduit, direct-buried cable, or duct bank in water.
2. Remove water in a manner that minimizes soil erosion from trench sides and bottom.
3. Provide continuous water control until trench backfill is complete.

B. Remove foreign material and backfill contaminated with foreign material that falls into trench.

3.02 TRENCH BOTTOM

A. Firm Subgrade: Grade with hand tools, remove loose and disturbed material, and trim off high areas and ridges left by excavating bucket teeth. Allow space for bedding material if shown or specified.

B. Soft Subgrade: If subgrade is encountered that may require removal to prevent pipe settlement, notify Contractor. Contractor will determine depth of overexcavation, if any required.

3.03 GEOTEXTILE INSTALLATION

A. Where shown and as specified in Section 31 32 19.16, Geotextile, except as follows:

1. Extend geotextile for full width of trench bottom and up the trench wall to the top of the pipe zone, or base material for manholes and miscellaneous structures.
2. Anchor geotextile trench walls prior to placing trench stabilization or bedding material.
3. Provide 24-inch minimum overlap at joints.

3.04 TRENCH STABILIZATION MATERIAL INSTALLATION

A. Install trench stabilization material where overexcavation of trench bottom is performed.

B. Rebuild trench bottom with trench stabilization material.

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C. Place material over full width of trench in 6-inch lifts to required grade, providing allowance for bedding thickness.

D. Compact each lift so as to provide a firm, unyielding support for the bedding material prior to placing succeeding lifts.

3.05 BEDDING

A. Furnish imported bedding material where, in the opinion of Contractor, excavated material is unsuitable for bedding or insufficient in quantity.

B. Place over full width of prepared trench bottom in two equal lifts when required depth exceeds 8 inches.

C. Hand grade and compact each lift to provide a firm, unyielding surface.

D. Minimum Thickness: As follows:

1. Pipe 15 Inches and Smaller: 4 inches.
2. Pipe 18 Inches to 36 Inches: 6 inches.
3. Pipe 42 Inches and Larger: 8 inches.
4. Conduit: 3 inches.
5. Direct-Buried Cable: 3 inches.
6. Duct Banks: 3 inches.

E. Check grade and correct irregularities in bedding material. Loosen top 1 inch to 2 inches of compacted bedding material with a rake or by other means to provide a cushion before laying each section of pipe, conduit, direct-buried cable, or duct bank.

F. Install to form continuous and uniform support except at bell holes, if applicable, or minor disturbances resulting from removal of lifting tackle.

G. Bell or Coupling Holes: Excavate in bedding at each joint to permit proper assembly and inspection of joint and to provide uniform bearing along barrel of pipe or conduit.

3.06 BACKFILL PIPE ZONE

A. Upper limit of pipe zone shall not be less than following:

1. Pipe: 12 inches, unless shown otherwise.
2. Conduit: 3 inches, unless shown otherwise.
3. Direct-Buried Cable: 3 inches, unless shown otherwise.
4. Duct Bank: 3 inches, unless shown otherwise.

B. Restrain pipe, conduit, cables, and duct banks as necessary to prevent their movement during backfill operations.

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C. Place material simultaneously in lifts on both sides of pipe and, if applicable, between pipes, conduit, cables, and duct banks installed in same trench.

1. Pipe 10-Inch and Smaller Diameter: First lift less than or equal to 1/2 pipe diameter.
2. Pipe Over 10-Inch Diameter: Maximum 6-inch lifts.

D. Thoroughly tamp each lift, including area under haunches, with handheld tamping bars supplemented by "walking in" and slicing material under haunches with a shovel to ensure voids are completely filled before placing each succeeding lift.

E. Do not use power-driven impact compactors to compact pipe zone material. After full depth of pipe zone material has been placed as specified, compact material by a minimum of three passes with a vibratory plate compactor only over area between sides of pipe and trench walls.

3.07 MARKING TAPE INSTALLATION

A. Continuously install marking tape along centerline of buried piping, as shown on Drawings. Coordinate with piping installation drawings.

1. Detectable Marking Tape: Install with nonmetallic piping and waterlines.

3.08 BACKFILL ABOVE PIPE ZONE

A. General:

1. Process excavated material to meet specified gradation requirements.
2. Adjust moisture content as necessary to obtain specified compaction.
3. Do not allow backfill to free fall into trench or allow heavy, sharp pieces of material to be placed as backfill until after at least 2 feet of backfill has been provided over top of pipe.
4. Do not use power driven impact type compactors for compaction until at least 4 feet of backfill is placed over top of pipe.
5. Backfill to grade with proper allowances for crushed rock surfacing, and pavement thicknesses, wherever applicable.
6. Backfill around structures with same class backfill as specified for adjacent trench, unless otherwise shown or specified.

3.09 MAINTENANCE OF TRENCH BACKFILL

A. After each section of trench is backfilled, maintain surface of backfilled trench even with adjacent ground surface until final surface restoration is completed.

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B. Gravel Surfacing Rock: Add gravel surfacing rock where applicable and as necessary to keep surface of backfilled trench even with adjacent ground surface, and grade and compact as necessary to keep surface of backfilled trenches smooth, free from ruts and potholes, and suitable for normal traffic flow.

C. Concrete Pavement: Replace settled slabs as specified in Section 32 12 16, Asphalt Paving.

D. Asphaltic Pavement: Replace settled areas or fill with asphalt as specified in Section 32 12 16, Asphalt Paving.

E. Other Areas: Add excavated material where applicable and keep surface of backfilled trench level with adjacent ground surface.

3.10 SETTLEMENT OF BACKFILL

A. Settlement of trench backfill, or of fill, or facilities constructed over trench backfill will be considered a result of defective compaction of trench backfill.

END OF SECTION

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SECTION 31 32 00
SOIL STABILIZATION

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards that may be referenced in this section:

1. Official Seed Analysts of North America.

1.02 DEFINITIONS

A. Maintenance Period: Begin maintenance immediately after each area is planted and continue for a period of 8 weeks after planting under this section is completed.

1.03 SUBMITTALS

A. Action Submittals: Product data for commercial products.

B. Informational Submittals:

1. Seed certifications.
2. Copies of delivery invoices or other proof of quantities of mulch, lime, and fertilizer.
3. Manufacturer's Installation Instructions: Commercial products.
4. Sub schedule of drainage, erosion, sedimentation control, and seeding.
5. Mixtures: Proportions of each kind of seed.
6. Description of required maintenance activities and activity frequency.

1.04 DELIVERY, STORAGE, AND PROTECTION

A. Seed:

1. Furnish in standard containers with seed name, lot number, net weight, percentages of purity, germination, and hard seed and maximum weed seed content, clearly marked for each container of seed.
2. Keep dry during storage.

B. Hydroseeding Mulch: Mark package of wood fiber mulch to show air dry weight.

1.05 SEQUENCING AND SCHEDULING

A. Prepare topsoil as specified in Section 32 91 13, Soil Preparation, before starting Work of this section.

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B. Complete soil preparation, seeding, liming, fertilizing, mulching and matting within 10 days after final grades have been reached.

C. Notify Contractor at least 3 days in advance of:

1. Materials delivery.
2. Start of planting/seeding activity.

D. Seeding: Perform under favorable weather conditions during seasons that are normal for such Work as determined by accepted local practice.

1.06 MAINTENANCE

A. Operations:

1. Perform during maintenance period to include:
   a. Washouts: Repair by filling with topsoil, fertilizing, seeding, and mulching.
   b. Mulch: Replace wherever and whenever washed or blown away.
   c. Reseed during next planting season if scheduled end of maintenance period falls after September 15.
   d. Watering as needed.
2. Inspect, repair, and replace as necessary all erosion control measures during the time period from start of construction to completion of construction.
3. Weed control as needed.

PART 2 PRODUCTS

2.01 FERTILIZER

A. Commercial, uniform in composition, free-flowing, suitable for application with equipment designed for that purpose.

B. Fertilizer as recommended by seed supplier and soil recommendations.

2.02 SEED

A. Fresh, clean new-crop seed that complies with tolerance for purity and germination established by Official Seed Analysts of North America.

B. Mix: Will be finalized pending coordination between Bureau of Land Management and Owner. Final BLM seed mix and execution will be added to appendix.

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2.03 MULCH

A. Wood Cellulose Fiber Mulch:

1. Specially processed wood fiber containing no growth or germination inhibiting factors.
2. Dyed suitable color to facilitate inspection of material placement.
3. Manufactured such that after addition and agitation in slurry tanks with water, material fibers become uniformly suspended to form homogenous slurry.
4. When hydraulically sprayed on ground, material will allow absorption and percolation of moisture.

2.04 EROSION CONTROL MATTING

A. Excelsior mat or straw blanket; staples as recommended by matting manufacturer.

B. Manufacturers and Products:

1. Akzo Industries, Asheville, NC; Curlex Mat.
2. North American Green, Evansville, IN; S150 blanket.

2.05 S150 BLANKET TACKIFIER

A. Derived from natural organic plant sources containing no growth or germination-inhibiting materials.

B. Capable of hydrating in water, and to readily blend with other slurry materials.

C. Wood Cellulose Fiber: Add as tracer, at rate of 150 pounds per acre.

D. Manufacturers and Products:

1. Chevron Asphalt Co.; CSS-1.
2. Terra; Tack AR.
3. J-Tack; Reclamare.

2.06 REINFORCED PLASTIC COVERING

A. Co-extruded, copolymer laminate reinforced with nonwoven grid of high strength nylon cord submersed in a permanently flexible adhesive media allowing for equal tear resistance in all directions.

B. Black in color and ultraviolet stabilized.

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C. Physical Requirement (Minimum Average Roll Values):

1. Tear Strength: 130 pounds.
2. Elongation: 620 percent.

D. Manufacturers:

1. Reef Industries, Inc., Houston, TX.
2. Griffolyn Co., Houston, TX.

PART 3 EXECUTION

3.01 SOIL PREPARATION

A. Before start of hydroseeding and after surface has been shaped and graded, and lightly compacted to uniform grade, scarify soil surface to minimum depth of 1 inch.

3.02 SEEDING

A. Prepare 1-inch-deep seed bed; obtain Contractor's acceptance prior to proceeding.

B. Apply by hydroseeding method on moist soil, but only after free surface water has drained away. Prevent drift and displacement of mixture into other areas.

C. Application: Will be finalized pending coordination between Bureau of Land Management and Owner. Final BLM seed mix and execution will be added to appendix.

3.03 MULCHING

A. Apply uniformly on seeded areas. Do not apply mulch on seeded areas that will be immediately covered with erosion control matting.

B. Application: Sufficiently loose to permit penetration of sunlight and air circulation, and sufficiently dense to shade ground, reduce evaporation rate, and prevent or materially reduce erosion of underlying soil.

1. Wood Cellulose Fiber: 1,000 to 1,500 pounds per acre.

3.04 EROSION CONTROL MATTING

A. Place on seeded slopes 3H:1V and steeper, staple/stake in place and with the appropriate overlap in accordance with manufacturer's instruction.

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3.05 TACKIFIER

A. Apply on areas mulched.

B. Spray on after mulch is in place.

C. Apply in quantities sufficient to equal retention properties of a CSS-1 asphalt emulsion being applied at rate of 400 gallons per acre.

END OF SECTION

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SECTION 31 32 19.16
GEOTEXTILE

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards that may be referenced in this section:

1. ASTM International (ASTM):
   a. D737, Standard Test Method for Air Permeability of Textile Fabrics.
   b. D4355, Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture and Heat in a Xenon Arc Type Apparatus.
   c. D4491, Standard Test Methods for Water Permeability of Geotextiles by Permittivity.
   d. D4533, Standard Test Method for Trapezoid Tearing Strength of Geotextiles.
   e. D4595, Standard Test Method for Tensile Properties of Geotextiles by the Wide-Width Strip Method.
   f. D4632, Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.
   g. D4716, Test Method for Determining the (In-Plane) Flow Rate per Unit Width and Hydraulic Transmissivity of a Geosynthetic Using a Constant Head.
   h. D4751, Standard Test Method for Determining Apparent Opening Size of a Geotextile.
   i. D4833, Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products.
   j. D4884, Standard Test Method for Strength of Sewn or Thermally Bonded Seams of Geotextiles.
   k. D4886, Standard Test Method for Abrasion Resistance of Geotextiles (Sand Paper/Sliding Block Method).
   l. D5199, Standard Test Method for Measuring the Nominal Thickness of Geosynthetics.
   m. D5261, Standard Test Method for Measuring Mass per Unit Area of Geotextiles.
   n. D6193, Standard Practice for Stitches and Seams.

1.02 DEFINITIONS

A. Fabric: Geotextile, a permeable geosynthetic comprised solely of textiles.

B. Maximum Average Roll Value (MaxARV): Maximum of series of average roll values representative of geotextile furnished.

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C. Minimum Average Roll Value (MinARV): Minimum of series of average roll values representative of geotextile furnished.

D. Nondestructive Sample: Sample representative of finished Work, prepared for testing without destruction of Work.

E. Overlap: Distance measured perpendicular from overlapping edge of one sheet to underlying edge of adjacent sheet.

F. Seam Efficiency: Ratio of tensile strength across seam to strength of intact geotextile, when tested according to ASTM D4884.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Manufacturer material specifications and product literature.
   b. Installation drawings showing geotextile sheet layout, location of seams, direction of overlap, and sewn seams.
   c. Description of proposed method of geotextile deployment, sewing equipment, sewing methods, and provisions for holding geotextile temporarily in place until permanently secured.

B. Informational Submittals:

1. Certifications from each geotextile manufacturer that furnished products have specified property values. Certified property values shall be either minimum or maximum average roll values, as appropriate, for geotextiles furnished.
2. Field seam efficiency test results.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Deliver each roll with sufficient information attached to identify it for inventory and quality control.

B. Handle products in manner that maintains undamaged condition.

C. Do not store products directly on ground. Ship and store geotextile with suitable wrapping for protection against moisture and ultraviolet exposure. Store geotextile in way that protects it from elements. If stored outdoors, elevate and protect geotextile with waterproof cover.

1.05 SCHEDULING AND SEQUENCING

A. Where geotextile is to be laid directly upon ground surface, prepare subgrade as specified in Section 31 23 13, Subgrade Preparation, first.

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PART 2 PRODUCTS

2.01 WOVEN GEOTEXTILE

A. Composed of polymeric yarn interlaced to form planar structure with uniform weave pattern.

B. Calendared or finished so yarns will retain their relative position with respect to each other.

C. Polymeric Yarn: Long-chain synthetic polymers (polyester or polypropylene) with stabilizers or inhibitors added to make filaments resistant to deterioration due to heat and ultraviolet light exposure.

D. Sheet Edges: Selvaged or finished to prevent outer material from separating from sheet.

E. Unseamed Sheet Width: Minimum **[A: 6] [B: 12] [C:]** feet.

F. Nominal Weight per Square Yard: **[A:]** per ASTM D5261.

G. Physical Properties: Conform to requirements in Table No. **[A:]**.

Table No. [A:]
Physical Property Requirements for Woven Geotextile

Property	Requirement	Test Method
Apparent Opening Size (AOS)	**[B:]** U.S. Standard Sieve Size	ASTM D4751
Water Permittivity	**[C:]** $sec.^{-1}$, MinARV	ASTM D4491 (Falling Head)
Vertical Waterflow Rate	**[D:]** gpm/sq ft, MinARV	ASTM D4491 (Falling Head)
Grab Tensile Strength	**[E:]** lb, MinARV	ASTM D4632
Grab Elongation	**[F:]** percent, MaxARV	ASTM D4632
Wide Width Strip Tensile Strength	**[G:]** lb/in.-width, MinARV	ASTM D4595
Wide Width Strip Elongation	**[H:]** percent, MaxARV	ASTM D4595
Trapezoidal Tear Strength	**[I:]** lb, MinARV	ASTM D4533
Puncture Strength	**[J:]** lb, MinARV	ASTM D4833

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Table No. [A:] Physical Property Requirements for Woven Geotextile		
Property	**Requirement**	**Test Method**
Abrasion Resistance	**[K:]** percent loss, 250 cycles, MaxARV	ASTM D4886
Ultraviolet Radiation Resistance	**[L:]** percent strength retention, MinARV after 500 hours	ASTM D4355

2.02 [BD1]NONWOVEN GEOTEXTILE

A. Pervious sheet of polyester, polypropylene, or polyethylene fabricated into stable network of fibers that retain their relative position with respect to each other. Nonwoven geotextile shall be composed of continuous or discontinuous (staple) fibers held together through needle-punching, spun-bonding, thermal-bonding, or resin-bonding.

B. Geotextile Edges: Selvaged or otherwise finished to prevent outer material from pulling away from geotextile.

C. Unseamed Sheet Width: Minimum 12 feet.

D. Nominal Weight per Square Yard: 6.5 ounces per ASTM D5261.

E. Physical Properties: Conform to requirements in Table No. 1.

Table No. 1 Physical Property Requirements for Nonwoven Geotextile		
Property	**Requirement**	**Test Method**
Water Permittivity	<1.8 $sec.^{-1}$, MinARV	ASTM D4491 (Falling Head)
Apparent Opening Size (AOS)	100 to 60 U.S. Standard Sieve Size	ASTM D4751
Grab Tensile Strength, Machine Direction	140 lb/in, MinARV	ASTM D4632
Grab Elongation, Machine Direction	50 percent, MaxARV	ASTM D4632
Puncture Strength	70 lb, MinARV	ASTM D4833
Trapezoid Tear Strength	60 lb, MinARV	ASTM D4533

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Table No. 1 Physical Property Requirements for Nonwoven Geotextile		
Property	**Requirement**	**Test Method**
Ultraviolet Radiation Resistance	70 percent strength retention, MinARV after 500 hours[BD2]	ASTM D4355

F. Acceptable fabrics include Mirafi 160N by TenCate Geosynthetics, or approved equal.

2.03 SEWING THREAD

A. Polypropylene, polyester, or Kevlar thread.

B. Durability: Equal to or greater than durability of geotextile sewn.

2.04 SECURING PINS

A. Steel Rods or Bars:

1. 3/16-inch diameter.
2. Pointed at one end.
3. With head on other end sufficiently large to retain washer.
4. Minimum Length: 12 inches.

B. Steel Washers for Securing Pins:

1. Outside Diameter: Not less than 1.5 inches.
2. Inside Diameter: 1/4 inch.
3. Thickness: 1/8 inch.

PART 3 EXECUTION

3.01 LAYING GEOTEXTILE

A. Lay and maintain geotextile smooth and free of tension, folds, wrinkles, or creases.

3.02 SHEET ORIENTATION ON SLOPES

A. Orient geotextile with long dimension of each sheet parallel to direction of slope.

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B. Geotextile may be oriented with long dimension of sheet transverse to direction of slope only if sheet width, without unsewn seams, is sufficient to cover entire slope and anchor trench and to extend at least 18 inches beyond toe of slope.

3.03 JOINTS

A. Unseamed Joints:

1. Overlapped.
2. Overlap, unless otherwise shown:
    a. Foundation/Subgrade Stabilization: Minimum 18 inches.
    b. Riprap: Minimum 18 inches.
    c. Drain Trenches: Minimum 18 inches, except overlap shall equal trench width if trench width is less than 18 inches.
    d. Other Applications: Minimum 12 inches.

B. Sewn Seams: Made wherever stress transfer from one geotextile sheet to another is necessary. Sewn seams, as approved by Contractor, also may be used instead of overlap at joints for applications that do not require stress transfer.

1. Seam Efficiency:
    a. Minimum 70 percent.
    b. Verified by preparing and testing minimum of one set of nondestructive Samples per acre of each type and weight of geotextile installed.
    c. Tested according to ASTM D4884.
2. Types:
    a. Preferred: “J” type seams.
    b. Acceptable: Flat or butterfly seams.
3. Stitch Count: Minimum three to maximum seven stitches per inch.
4. Stitch Type: Double-thread chainstitch according to ASTM D6193.
5. Sewing Machines: Capable of penetrating four layers of geotextile.
6. Stitch Location: 2 inches from geotextile sheet edges, or more, if necessary to develop required seam strength.

3.04 SECURING GEOTEXTILE

A. Secure geotextile during installation as necessary with sandbags or other means approved by Contractor.

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B. Secure Geotextile with Securing Pins or Staples:

1. Insert securing pins with washers through geotextile.
2. Securing Pin Alignment:
   a. Midway between edges of overlaps.
   b. 6 inches from free edges.
3. Spacing of Securing Pins:

Slope	Maximum Pin Spacing
Steeper than 3:1	2 feet
3:1 to 4:1	3 feet
Flatter than 4:1	5 feet

4. Install additional pins across each geotextile sheet as necessary to prevent slippage of geotextile or to prevent wind from blowing geotextile out of position.
5. Push each securing pin through geotextile until washer bears against geotextile and secures it firmly to subgrade.

3.05 PLACING PRODUCTS OVER GEOTEXTILE

A. If tears, punctures, or other geotextile damage occurs during placement of overlying products, remove overlying products as necessary to expose damaged geotextile. Repair damage as specified in Article Repairing Geotextile.

3.06 INSTALLING GEOTEXTILE IN TRENCHES

A. Place geotextile in a way to completely envelope granular drain material to be placed in trench and with specified overlap at joints. Overlap geotextile in direction of flow. Place geotextile in a way and with sufficient slack for geotextile to contact trench bottom and sides fully when trench is backfilled.

B. After granular drain material is placed to required grade, fold geotextile over top of granular drain material, unless otherwise shown. Maintain overlap until overlying fill or backfill is placed.

3.07 RIPRAP APPLICATIONS

A. Overlap geotextile at each joint with upstream sheet of geotextile overlapping downstream sheet.

B. Sew joints where wave run-up may occur.

C. Limit height of riprap fall onto geotextile to prevent damage.

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3.08 SILT FENCE APPLICATIONS

A. Install geotextile in one piece, or continuously sewn to make one piece, for full length and height of fence, including portion of geotextile buried in toe trench.

B. Install bottom edge of sheet in toe trench and backfill in a way that securely anchors geotextile in trench.

C. Securely fasten geotextile to wire mesh backing and each support post in a way that will not result in tearing of geotextile when fence is subjected to service loads.

D. Promptly repair or replace silt fence that becomes damaged.[BD3]

3.09 REPAIRING GEOTEXTILE

A. Repair or replace torn, punctured, flawed, deteriorated, or otherwise damaged geotextile.

B. Repair Procedure:

1. Place patch of undamaged geotextile over damaged area and at least 18 inches in all directions beyond damaged area.
2. Remove interfering material as necessary to expose damaged geotextile for repair.
3. Sew patches or secure them with heat fusion tacking or with pins and washers, as specified above in Article Securing Geotextile, or by other means approved by Contractor.

3.10 REPLACING CONTAMINATED GEOTEXTILE

A. Protect geotextile from contamination that would interfere, in Contractor's opinion, with its intended function. Remove and replace contaminated geotextile with clean geotextile.

END OF SECTION

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SECTION 31 37 00
RIPRAP

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   a. C94/C94M, Standard Specification for Ready-Mixed Concrete.
   b. C136, Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
   c. C150, Standard Specification for Portland Cement.
   d. C535, Standard Test Method for Resistance to Degradation of Large-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.

1.02 DEFINITIONS

A. Refer to applicable definitions in Section 31 23 23, Fill and Backfill.

B. Standard Specifications, as used in this section, refer to New Mexico Standard for Public Works Construction.

1.03 SUBMITTALS

A. Informational Submittals:

1. Quarry Certificate of Conformance and supporting documentation showing proposed riprap bedding or riprap meet Standard Specification gradation and materials requirements for the Class or Type specified.
2. Certified Test Results:
   a. Riprap Bedding:
      1) Gradation.
      2) Abrasion resistance.
   b. Riprap:
      1) Gradation.
      2) Abrasion resistance.
      3) Bulk density.
3. Trip tickets showing source, type, and weight of each load of material delivered to Site.

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1.04 QUALITY ASSURANCE

A. Riprap Source: Quarry that has produced riprap and has performed satisfactorily on other projects for at least 5 years.

1.05 SCHEDULING AND SEQUENCING

A. Complete subgrade preparation as specified in Section 31 23 13, Subgrade Preparation, and geotextile installation as specified in Section 31 32 19.16, Geotextile, prior to placing riprap bedding or riprap.

PART 2 PRODUCTS

2.01 AGGREGATE RIPRAP BEDDING

A. Gravel with Cobbles or Crushed Rock with Cobble-Sized Pieces:

1. Gradation, as determined in accordance with ASTM C136:
   a. Well-graded from coarse to fine.
   b. All pieces pass a 6-inch square opening.
   c. Minimum 85 percent by weight passes 4-inch square opening.
   d. Minimum 10 percent by weight passes No. 4 U.S. standard sieve.
2. Abrasion Resistance: Maximum 35 percent wear when tested in accordance with ASTM C535.

B. Free of roots and other organic or deleterious matter.

C. Onsite material from excavations or designated borrow sources that meets or is processed to meet requirements specified above may be used as riprap bedding in lieu of importing material.

2.02 RIPRAP

A. Riprap stone shall meet the requirements of Section 109 of the Standard Specifications, in addition to the following.

B. Hard and durable quarry stone free from fractures, bedding planes, pronounced weathering, and earth or other adherent coatings.

C. Minimum Dimension of Individual Pieces: Not less than 1/3 maximum dimension.

D. Abrasion Resistance: Maximum 35 percent wear as determined in accordance with ASTM C535.

E. Bulk Density: Minimum 160 pounds per dry cubic foot.

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F. Gradation: Smaller pieces shall generally fill voids between larger pieces without either excess or deficiency of one or more sizes of stone.

Type	Mean Particle Size	Max Dimensions (Inches)	% Smaller
		24	100
		18	50-70
		12	30-55
M	12	6	10
		36	100
		24	50-70
H	18	12	30-55
		48	100
		36	50-70
		18	30-55
VH	24	9	10

2.03 CONCRETE GROUT

A. Portland cement concrete as specified in Section 03 30 00, Cast-in-Place Concrete, having a 28-day compressive strength of 3,000 psi.

PART 3 EXECUTION

3.01 PLACING RIPRAP BEDDING

A. No mechanical compaction of riprap bedding is required; however, work riprap bedding as necessary to distribute it and to eliminate detrimental voids. Avoid overworking or long pushes that result in segregation of particle sizes.

B. Grade surface of riprap bedding free from irregularities and to tolerances of 0.2 feet from established grade.

C. Place and grade riprap bedding in a manner that avoids subgrade disturbance and displacement or damage to geotextile. Do not push riprap bedding down slope. If wrinkles form in geotextile as riprap bedding is placed, correct them as specified in Section 31 32 19.16, Geotextile.

D. Place riprap bedding on geotextile without puncturing or damaging geotextile. If accidentally damaged, repair geotextile prior to proceeding.

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3.02 PLACING RIPRAP ON RIPRAP BEDDING

A. Place riprap over riprap bedding to uniform thickness shown. If riprap bedding is underlain with geotextile, place riprap from bottom to top of slope.

B. Intermix different sizes of pieces to eliminate segregation and to fill voids between larger pieces with smaller pieces and work surface free from irregularities.

C. Use placement and intermixing methods that avoid disturbing riprap bedding and underlying geotextile or damaging existing facilities, completed Work, or adjacent property.

3.03 GROUTING RIPRAP

A. Remove dirt and foreign substances from surfaces of riprap and then moisten.

B. Deposit grout by means of chutes, tubes, or buckets, or place by means of pneumatic equipment or other mechanical methods. Place grout in a continuous operation for any day's run at any one location.

C. Limit flow distance of grout along slope to less than 10 feet.

D. Spade and rod grout into place with suitable spades, trowels, or other approved means immediately after depositing grout. Depths of grout shall be approximately 1/2 the thickness of the riprap.

E. Following placement of grout, thoroughly brush rocks so top surfaces are exposed. Outer rocks shall project 1/3 to 1/4 their diameter above grout surface. Brushing shall follow closely behind rodding such that grout shall not be in place more than 1 hour before brushing.

F. Once brushing of area is complete, no worker or load will be permitted on surface for period of at least 24 hours, or longer if so required by Contractor.

G. Cure grout as provided in Section 03 30 00, Cast-in-Place Concrete.

END OF SECTION

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SECTION 32 11 23
AGGREGATE BASE COURSES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Association of State Highway and Transportation Officials (AASHTO):
   a. T11, Standard Method of Test for Materials Finer Than 75μm (No. 200) Sieve in Mineral Aggregates by Washing.
   b. T27, Standard Method of Test for Sieve Analysis of Fine and Coarse Aggregates.
   c. T89, Standard Specification for Determining the Liquid Limit of Soils.
   d. T90, Standard Specification for Determining the Plastic Limit and Plasticity Index of Soils.
   e. T96, Standard Specification for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.
   f. T99, Standard Specification for the Moisture-Density Relations of Soils Using a 2.5 kg (5.5 pound) Rammer and a 305 mm (12 in) Drop.
   g. T180, Standard Specification for Moisture-Density Relations of Soils Using a 4.54 kg (10-lb) Rammer and a 457 mm (18-in) Drop.
   h. T190, Standard Specification for Resistance R-Value and Expansion Pressure of Compacted Soils.
   i. T265, Standard Method of Test for Laboratory Determination of Moisture Content of Soils.
   j. T310, Standard Specification for In-Place Density and Moisture Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).
2. ASTM International (ASTM):
   a. C88, Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate.
   b. D1883, Test Method for CBR (California Bearing Ratio) of Laboratory Compacted Soils.
   c. D2419, Test Method for Sand Equivalent Value of Soils and Fine Aggregate.
   d. D4791, Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate.

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1.02 DEFINITIONS

A. Completed Course: Compacted, unyielding, free from irregularities, with smooth, tight, even surface, true to grade, line, and cross-section.

B. Completed Lift: Compacted with uniform cross-section thickness.

C. Standard Specifications: When referenced in this section, shall mean FP14, the standard specifications for the construction of roads and bridges on federal highway projects.

1.03 SUBMITTALS

A. Per Standard Specifications.

PART 2 PRODUCTS

2.01 AGGREGATE SUBBASE COURSE

A. As specified in Section 703.05 “Subbase, Base, and Surface Course Aggregate” of the Standard Specifications.

2.02 AGGREGATE BASE COURSE

A. As specified in Section 703.05 “Subbase, Base, and Surface Course Aggregate” of the Standard Specifications.

2.03 GRAVEL SURFACING

A. As specified in Section 703.05 “Subbase, Base, and Surface Course Aggregate” of the Standard Specifications.

2.04 SOURCE QUALITY CONTROL

A. Perform tests necessary to locate acceptable source of materials meeting specified requirements.

B. Final approval of aggregate material will be based on test results of installed materials.

C. Should separation of coarse from fine materials occur during processing or stockpiling, immediately change methods of handling materials to correct uniformity in grading.

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PART 3 EXECUTION

3.01 SUBGRADE PREPARATION

A. As specified in Section 31 23 13, Subgrade Preparation.

B. Obtain Contractor's acceptance of subgrade before placing base course or surfacing material.

C. Do not place base course or surfacing materials in snow or on soft, muddy, or frozen subgrade.

3.02 EQUIPMENT

A. In accordance with the Standard Specifications.

3.03 HAULING AND SPREADING

A. In accordance with the Standard Specifications.

B. Hauling Materials:

1. Do not haul over surfacing in process of construction.
2. Loads: Of uniform capacity.
3. Maintain consistent gradation of material delivered; loads of widely varying gradations will be cause for rejection.

C. Spreading Materials:

1. Distribute material to provide required density, depth, grade, and dimensions with allowance for subsequent lifts.
2. Produce even distribution of material upon roadway or prepared surface without segregation.
3. Should segregation of coarse from fine materials occur during placing, immediately change methods of handling materials to correct uniformity in grading.

3.04 CONSTRUCTION OF COURSES

A. Construction of Courses: In accordance with the Standard Specifications.

B. Untreated Aggregate Base Course:

1. Maximum Completed Lift Thickness: 6 inches.
2. Completed Course Total Thickness: As shown.
3. Spread lift on preceding course to required cross-section.
4. Lightly blade and roll surface until thoroughly compacted.

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5. Add keystone to achieve compaction and as required when aggregate does not compact readily due to lack of fines or natural cementing properties, as follows:
    a. Use leveling course or surfacing material as keystone.
    b. Spread evenly on top of base course, using spreader boxes or chip spreaders.
    c. Roll surface until keystone is worked into interstices of base course without excessive displacement.
    d. Continue operation until course has become thoroughly keyed, compacted, and will not creep or move under roller.
6. Blade or broom surface to maintain true line, grade, and cross-section.

C. Gravel Surfacing:

1. Maximum Completed Lift Thickness: 6 inches.
2. Completed Course Total Thickness: As shown.
3. Spread on preceding course in accordance with cross-section shown.
4. Blade lightly and roll surface until material is thoroughly compacted.

3.05 ROLLING AND COMPACTION

A. In accordance with the Standard Specifications.

B. Commence rolling at outer edges and continue toward center; do not roll center of road first.

C. Apply water as needed to obtain specified densities.

D. Place and compact each lift to required density before succeeding lift is placed.

E. Remove floating or loose stone from surface of preceding course before placing leveling course.

F. Surface Defects: Remedy by loosening and rerolling. Reroll entire area, including surrounding surface, until thoroughly compacted.

G. Finished surface shall be true to grade and crown before proceeding with surfacing.

3.06 SURFACE TOLERANCES

A. Blade or otherwise work surfacing as necessary to maintain grade and cross-section at all times, and to keep surface smooth and thoroughly compacted.

B. Finished Surface of Untreated Aggregate Base Course: Within plus or minus 0.04 foot of grade shown at any individual point.

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C. Gravel Surfacing: Within 0.04 foot from lower edge of 10-foot straightedge placed on finished surface, parallel to centerline.

D. Overall Average: Within plus or minus 0.01 foot from crown and grade specified.

3.07 DRIVEWAY RESURFACING

A. Replace gravel surfacing on driveways that were gravel surfaced prior to construction.

B. Provide compacted gravel surfacing to depth equal to original, but not less than 4 inches.

C. Leave each driveway in as good or better condition as it was before start of construction.

3.08 FIELD QUALITY CONTROL

A. In-Place Density Tests: In conformance with Standard Specifications.

3.09 CLEANING

A. Remove excess material from the Work area. Clean stockpile and staging areas of all excess aggregate.

END OF SECTION

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SECTION 32 17 23
PAVEMENT MARKINGS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Association of State Highway and Transportation Officials (AASHTO):
   a. M237, Standard Specification for Epoxy Resin Adhesives for Bonding Traffic Markers to Hardened Portland Cement and Asphalt Concrete.
   b. M247, Standard Specification for Glass Beads Used in Traffic Paint.
   c. M248, Standard Specification for Ready-Mixed White and Yellow Traffic Paints.
   d. M249, Standard Specification for White and Yellow Reflective Thermoplastic Striping Material (Solid Form).
2. ASTM International (ASTM): D4280, Standard Specification Extended Life Type, Nonplowable, Prismatic, Raised, Retroreflective Pavement Markers.
3. Federal Specifications (FS):
   a. A-A-2886A, Paint, Traffic, Solvent Based.
   b. TT-B-1325C, Beads (Glass Spheres); Retroreflective.

1.02 DEFINITIONS

A. Standard Specifications: FP14, Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects.

PART 2 PRODUCTS

2.01 GENERAL

A. All products shall be in accordance with Section 634 of the Standard Specifications for Type K, nonreflectorized markings.

2.02 PAINT

A. Paint shall be solvent borne or waterborne traffic paint in accordance with Section 634 of the Standard Specifications.

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PART 3 EXECUTION

3.01 GENERAL

A. Surface Preparation, Application, and Protection: In accordance with the Standard Specifications.

3.02 SURFACE PREPARATION

A. Cleaning:

1. Thoroughly clean surfaces to be marked before application of pavement marking material.
2. Remove dust, dirt, and other granular surface deposits by sweeping, blowing with compressed air, rinsing with water or a combination of these methods.
3. Completely remove rubber deposits, surface laitance, existing paint markings, and other coatings adhering to pavement with scrapers, wire brushes, sandblasting, approved chemicals, or mechanical abrasion.
4. Scrub areas of old pavement affected with oil or grease with several applications of trisodium phosphate solution or other approved detergent or degreaser, and rinse thoroughly after each application.
5. Surfaces shall be completely free of dirt and ice, and dry of water at the time of application of materials specified herein.
6. Oil-Soaked Areas: After cleaning, seal with cut shellac to prevent bleeding through the new paint.
7. Reclean surfaces when the Work has been stopped due to rain.

B. Pretreatment for Early Painting: Where painting is required prior to 30 days after paving rigid pavements, pretreat with an aqueous solution containing 3 percent phosphoric acid and 2 percent zinc chloride.

C. New Concrete Pavement:

1. Allow a minimum cure time of 30 days before cleaning and marking.
2. Clean by either sandblasting or water blasting to the following results:
   a. No visible evidence of curing compound on peaks of textured concrete surface.
   b. No heavy puddled deposits of curing compound in valleys of textured concrete surface.
   c. Remaining curing compound is intact, with loose and flaking material completely removed.
   d. Peaks of textured pavement surface are rounded in profile and free of sharp edges and irregularities.
3. Allow a minimum drying time of 24 hours after water blasting before applying thermoplastic markings.

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3.03 PAINT APPLICATION

A. General:

1. Thoroughly mix pigment and vehicle together prior to application, and keep thoroughly agitated during application.
2. Do not add thinner.
3. Apply only when air and pavement temperatures are above 50 degrees F and less than 95 degrees F. Maintain paint temperature within these same limits.
4. Apply only when surface is dry.
5. Do not apply when conditions are windy to the point of causing overspray or fuzzy line edges.
6. Provide guidelines and templates to control paint application.
7. Take special precautions in marking numbers, letters, and symbols.
8. Sharply outline edges of markings and apply without running or spattering.

B. Rate of Application:

1. Nonreflective Markings: Apply paint evenly to pavement surface at a rate of 105 plus or minus 5 square feet per gallon.
2. On new pavement surface treatments, apply two coats of paint at a uniform rate of 210 square feet per gallon.

C. Drying:

1. Provide maximum drying time to prevent undue softening of bitumen and pickup, displacement, or discoloration by traffic.
2. If drying is abnormally slow, discontinue painting operations until cause is determined and corrected.

D. Protection:

1. Protect markings from traffic until paint is thoroughly dry.
2. Protect surfaces from disfiguration by paint spatters, splashes, spills, or drips.

E. Cleanup: Remove paint spatters, splashes, spills, or drips from the Work and staging areas including areas outside the immediate Work area where spills occur.

END OF SECTION

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SECTION 32 31 13
CHAIN LINK FENCES AND GATES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   a. A121, Standard Specification for Metallic-Coated Carbon Steel Barbed Wire.
   b. A313/A313M, Standard Specification for Stainless Steel Spring Wire.
   c. A392, Standard Specification for Zinc-Coated Steel Chain-Link Fence Fabric.
   d. A491, Standard Specification for Aluminum-Coated Steel Chain-Link Fence Fabric.
   e. A497/A497M, Standard Specification for Steel Welded Wire Reinforcement, Deformed, for Concrete.
   f. A615/A615M, Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.
   g. A780, Standard Specification for Repair of Damaged and Uncoated Areas of Hot-Dipped Galvanized Coatings.
   h. A824, Standard Specification for Metallic-Coated Steel Marcelled Tension Wire for Use with Chain Link Fence.
   i. A1011/A1011M, Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability.
   j. C94/C94M, Standard Specification for Ready-Mixed Concrete.
   k. C150, Standard Specification for Portland Cement.
   l. C387, Standard Specifications for Packaged, Dry, Combined Materials for Mortar and Concrete.
   m. F552, Standard Terminology Relating to Chain Link Fencing.
   n. F567, Standard Practice for Installation of Chain-Link Fence.
   o. F626, Standard Specification for Fence Fittings.
   p. F668, Standard Specification for Polyvinyl Chloride (PVC) and Other Organic Polymer-Coated Steel Chain-Link Fence Fabric.
   q. F900, Standard Specification for Industrial and Commercial Swing Gates.
   r. F934, Standard Specification for Standard Colors for Polymer-Coated Chain Link Fence Materials.
   s. F1043, Standard Specification for Strength and Protective Coatings on Metal Industrial Chain Link Fence Framework.

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t. F1083, Standard Specification for Pipe, Steel, Hot-Dipped Zinc-Coated (Galvanized) Welded, for Fence Structures.
u. F1183, Standard Specifications for Aluminum Alloy Chain Link Fence Fabric.
v. F1184, Standard Specifications for Industrial and Commercial Horizontal Slide Gates.
w. F1379, Standard Terminology Relating to Barbed Tape.
x. F1911, Standard Practice for Installation of Barbed Tape.
y. F1916, Standard Specification for Selecting Chain Link Barrier Systems with Coated Chain Link Fence Fabric and Round Posts for Detention Applications.

2. Institute of Electrical and Electronic Engineers (IEEE), Inc.: C2, National Electrical Safety Code.
3. National Electrical Manufacturers Association (NEMA): 250, Enclosures for Electrical Equipment (1,000 volts max.).

1.02 DEFINITIONS

A. Terms as defined in ASTM F552.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Product Data: Include construction details, material descriptions, dimensions of individual components, and finishes for chain link fences and gates.
      1) Fence, gate posts, rails, and fittings.
      2) Chain link fabric.
      3) Gates and hardware.
      4) Gate operators, motors, and mounting arrangements, switches, and controls; include operating instructions.
      5) Gate access system, including access control features, power and control wiring diagrams, and operating instructions.
      6) Accessories: Barbed wire and Privacy slats.
2. Test Reports: Field test result for compliance of installation of chain link fence, gates, and gate operators.

B. Informational Submittals:

1. Manufacturer’s recommended installation instructions.
2. Evidence of Supplier and installer qualifications.
3. Operation and Maintenance Data as specified in Section 01 78 23, Operation and Maintenance Data**.**

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1.04 QUALITY ASSURANCE

A. Qualifications:

1. Automatic Gate Operator System Supplier: 5 years' experience in gate operator systems.
2. Automatic Gate Operator System Installer: Experienced installer who has completed chain link fences and gates similar in material, design, and extent to those indicated for Project and whose work has resulted with a record of successful in-service performance with a minimum 3 years' experience.

B. Design, supply of equipment and components, installation, and on-call service shall be product of individual company with record of installations meeting requirements specified.

C. Preinstallation Conference: Conduct conference at project Site with gate installer to verify layout and operations of automatic gate operating system.

1.05 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to Site in undamaged condition. Store materials off the ground to provide protection against oxidation caused by ground contact.

1.06 SCHEDULING AND SEQUENCING

A. Complete necessary Site preparation and grading before installing chain link fence and gates.

B. Interruption of Existing Utility Service: Notify owner of utility 72 hours prior to interruption of utility services. Do not proceed with interruption of utility service without written permission from utility owner.

1.07 SPECIAL GUARANTEE

A. Provide manufacturer's extended guarantee or warranty, with Owner named as beneficiary, in writing, as special guarantee. Special guarantee shall provide for correction, or at the option of the Owner, removal and replacement of the following items found defective during a period of 5 years after the date of Substantial Completion. Duties and obligations for correction or removal and replacement of defective Work shall be as specified in the General Conditions.

1. Faulty operations of gate operators and controls.
2. Deterioration of metals, metal finishes, and other materials beyond normal weathering.
3. Deflection of fence fabric beyond limits.

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PART 2 PRODUCTS

2.01 GENERAL

A. Match style, finish, and color of each fence component with that of other fence components.

2.02 CHAIN LINK FENCE FABRIC

A. Non-reflective galvanized fabric conforming to ASTM A392, Type II, Class 1, 1.2 ounces per square foot.

B. PVC-coated or Polymer-coated galvanized fabric conforming to ASTM F668, Class 1 or Class 2a over metallic-coated steel wire.

1. Color: Brown, complying with ASTM F934.

C. Height: 96 inches, unless otherwise shown.

D. Core Wire Gauge: No. 9.

E. Pattern: 2-inch diamond-mesh.

F. Diamond Count: Manufacturer’s standard and consistent for fabric furnished of same height.

G. Loops of Knuckled Selvages: Closed or nearly closed with space not exceeding diameter of wire.

H. Wires of Twisted Selvages:

1. Twisted in a closed helix three full turns.
2. Cut at an angle to provide sharp barbs that extend minimum 1/4 inch beyond twist.

2.03 POSTS

A. General:

1. Strength and Stiffness Requirements: ASTM F1043, heavy industrial fence, except as modified in this section.
2. Round Steel Pipe, Schedule 40: ASTM F1083.
3. Roll-Formed Steel Shapes: Roll-formed from ASTM A1011/A1011M, Grade 45, High-Strength Low-Alloy steel.
4. Lengths: Manufacturer’s standard with allowance for minimum embedment below finished grade of 34 inches.

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5. Protective Coatings:
    a. Zinc Coating: ASTM F1043, Type A external and internal coating.
6. Color Coating: ASTM F1043, minimum 10 mils thickness over zinc coating to match color of chain link fabric.

B. Line Posts:

1. Round Steel Pipe:
    a. Outside Diameter: 2.375 inches.
    b. Weight: 3.65 pounds per foot.

C. End, Corner, Angle, and Pull Posts:

1. Round Steel Pipe:
    a. Outside Diameter: 2.875 inches.
    b. Weight: 5.79 pounds per foot.

D. Posts for Removable Fence Panels: As specified for end, corner, angle, and pull posts.

E. Posts for Horizontal Sliding Gates:

1. ASTM F1184, Type II, Class 1**.**
2. Round Steel Pipe:
    a. Outside Diameter: 6.625 inches.
    b. Weight: 8.02 pounds per foot.
3. Guide posts for Class 1 horizontal-slide gates, equal gate post height, one size smaller, but weight is not less than 3.11 pounds per foot, installed adjacent to gate post to permit gate to slide in space between.

2.04 TOP AND BRACE RAILS

A. Galvanized Round Steel Pipe:

1. ASTM F1083.
2. Outside Diameter: 1.66 inches.
3. Weight: 2.27 pounds per foot.

B. Galvanized Roll-Formed Steel C Shapes:

1. Roll formed from ASTM A1011/A1011M, Grade 45.
2. Outside Dimensions: 1.625 inches by 1.25 inches.
3. Weight: 1.40 pounds per foot.

C. Protective Coatings: As specified for posts.

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D. Color Coating: ASTM F1043, minimum 10-mil thickness over zinc coating to match color of chain link fabric.

E. Strength and Stiffness Requirements: ASTM F1043, top rail, heavy industrial fence.

2.05 FENCE FITTINGS

A. General: In conformance with ASTM F626, except as modified by this article.

B. Post and Line Caps: Designed to accommodate passage of top rail through cap, where top rail required.

C. Tension and Brace Bands: Vinyl-clad.

D. Tension Bars:

1. One-piece vinyl-clad**.**
2. Length not less than 2 inches shorter than full height of chain link fabric.
3. Provide one bar for each gate and end post, and two for each corner and pull post.

E. Truss Rod Assembly: 3/8-inch diameter, steel, hot-dip galvanized after threading rod and turnbuckle or other means of adjustment.

F. Tie Wires, Clips, and Fasteners: According to ASTM F626.

G. Barbed Wire Supporting Arms: Pressed steel or cast iron with clips, slots, or other means for attaching strands of barbed wire integral with post cap for each post, with single 45-degree arms for supporting three strands of barbed wire. Arms shall withstand 250 pounds of downward pull at outermost ends of the arms without failure.

2.06 TENSION WIRE

A. Zinc-coated steel marcelled tension wire conforming to ASTM A824 Type II, Class 2**.**

2.07 BARBED WIRE

A. Zinc-Coated Barbed Wire: ASTM A121, Chain Link Fence Grade:

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2.08 GATES

A. General:

1. Gate Operation: Opened and closed easily by one person.
2. Metal Pipe and Tubing: Galvanized steel. Comply with ASTM F1043 and ASTM F1083 for materials and protective coatings.
3. Frames and Bracing: Fabricate members from round galvanized steel tubing with outside dimension and weight according to ASTM F900.
4. Gate leaves more than 8-feet wide shall have intermediate tubular members and diagonal truss rods to provide rigid construction, free from sag or twist.
5. Gate Fabric Height: Same as for adjacent fence height.
6. Welded Steel Joints: Paint with zinc-based paint.
7. Chain Link Fabric: Attached securely to gate frame at intervals not exceeding 15 inches.
8. Gate Posts and Frame Members: Extend gateposts and frame end members above top of chain-link fabric at both ends of gate frame to attach barbed wire or tape assemblies.
9. Latches: Arranged for padlocking so padlock will be accessible from both sides of gate.

B. Horizontal Sliding Gates:

1. Track Rollers: Malleable iron or heavy pressed steel with provision for grease lubrication.
2. Ground Rollers: Malleable iron or heavy pressed steel with provision for grease lubrication.
3. Support Posts: Spaced on maximum 7-foot centers.
4. Gates more than 8 feet in height shall have three tracks.
5. Frames: ASTM F1184, Type I.
6. Gate Accessories: ASTM F1184.

2.09 GATE OPERATOR SYSTEM

A. General: Provide factory-assembled automatic operating system designed for gate size, type, weight, and operation frequency. Provide operation control system with characteristics suitable for Project conditions, safety devices, and weatherproof enclosures; coordinate electrical requirements with Division 26, Electrical.

1. Provide operator designed so motor may be removed without disturbing limit-switch adjustment and without affecting auxiliary emergency operator.
2. Provide operator with UL approved components.

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3. Provide electronic components with built-in troubleshooting diagnostic feature.
4. Provide unit designed and wired for both right-hand/left-hand opening, permitting universal installation.

B. Motor Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, within installed environment, with indicated operating sequence, and without exceeding nameplate rating or considering service factor.

C. Gate Operator:

1. Heavy-duty, high frequency, electrical models designed to open and close gates provided.
2. For each gate, supply manufacturer of gate operator with complete details of gate, hardware, track rollers, adjacent fence posts, and fence construction for development and detailing of gate operator.
3. Furnish with following features:
    a. Metal enclosure, including attachments shall be constructed with finish and design suitable for exterior installation in all-weather environment.
    b. Minimum 1-hp motor, 460V ac, three-phase, 60-Hz electric power, reversible.
    c. Electric motor driven hydraulic power pack with hard rubber wheels in contact with operating type secured to gate. Transmission of opening or closing forces to gate shall be by rotation of wheels against operating type.
    d. Positive limit switch, to sense position of gate and provide control to prevent damage to gate operator.
    e. NEMA 250, Type 4X stainless steel enclosure for motor control components.
    f. Motor Overload Protection: Industrial quality with manual reset.
    g. 24V ac control circuit to power remote control gate activation devices.
    h. Manual operation feature or disconnect, without use of tools, for easy operation during power failure, malfunction, or emergency.
    i. Aluminum drive rail designed for attachment to sliding gate in manner that reinforces gate assembly.
    j. Gate Travel Speed:
        1) Minimum 1 foot per second.
        2) Speed adjusting feature that provides range of appropriate speeds for slide gate operation is acceptable but not required.
        3) Maximum Gate Weight: 3,000 pounds.

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4) Frequency of Use: Continuous Duty.
5) Operating Type: Roller chain with manual release.

k. Compatible with gate operator control devices provided.

4. Manufacturers:
   a. Hy-Security Gate Operator, Seattle, WA.
   b. Automated Equipment Co., Seattle, WA.
   c. Stanley.
   d. Richards Wilcox, Aurora, IL.

D. Access System: Card reader as specified in Section 28 13 00, Security Systems.

2.10 PRIVACY SLATS

A. Material: Polyethylene tubular slats, not less than 0.023-inch thick, manufactured for chain link fences from virgin polyethylene containing UV inhibitor, sized to fit mesh specified for direction indicated with vandal-resistant fasteners and lock strips.

B. Color: Manufacturer's standard tan and as shown.

C. Fabric Selvage: Knuckled.

D. Furnish continuous galvanized top rail, manufacturer's standard heavyweight galvanized line, corner, gate, and end posts, and accessories and fasteners.

E. Gates: Manufacturer's standard for use with chain link, wood slat fence. Furnish galvanized hardware for complete gate installation.

F. Hardware: Galvanized.

2.11 REMOVABLE FENCE PANELS

A. Panel Length:

1. Equal division of total length of removable fence section.
2. Maximum 10 feet.

B. Frames: ASTM F1184, Type I.

2.12 CONCRETE

A. Provide as specified in Section 03 30 00, Cast-in-Place Concrete.

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2.13 FENCE GROUNDING

A. Conductors: Bare, solid wire for No. 6 AWG and smaller; stranded wire for No. 4 AWG and larger.

1. Material above Finished Grade: Copper.
2. Material on or below Finished Grade: Copper.
3. Bonding Jumpers: Braided copper tape, 1-inch wide, woven of No. 30 AWG bare copper wire, terminated with copper ferrules.

B. Connectors: Comply with UL 467.

1. Connectors for Below-Grade Use: Exothermic welded type.
2. Grounding Electrodes: Copper-clad steel ground rods, 3/4-inch diameter, 10 feet long, minimum.

PART 3 EXECUTION

3.01 GENERAL

A. Install chain link fences and gates in accordance with ASTM F567, except as modified in this section, and in accordance with fence manufacturer's recommendations, as approved by Contractor. Erect fencing in straight lines between angle points.

B. Provide necessary hardware for a complete fence and gate installation.

C. Any damage to galvanized surfaces, including welding, shall be repaired with paint containing zinc dust in accordance with ASTM A780.

D. Drainage Crossings: Where the chain-link fence must cross drainage ditches or swales, the main fence shall be carried across a ditch or swale with additional fence added below.

1. Frames and Bracing: The fence added below shall be fabricated with galvanized round steel pipe conforming to the requirements for top and brace rails.
2. The construction of the frame shall be welded or assembled with corner fittings. The frame shall be rigid and to the extent necessary to maintain a 2-inch clearance between bottom of the frame and finish grade. If necessary to maintain rigidity, attach to the frame a series of 3/8-inch diameter galvanized steel pipe stakes that are embedded a minimum of 2 feet to the sides and bottom of the ditch.
3. Attach chain link fabric securely to frame at intervals not exceeding 12 inches.

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3.02 PREPARATION

A. Clear area on either side of fence to the extent specified in Section 31 10 00, Site Clearing. Eliminate ground surface irregularities along fence line to the extent necessary to maintain a 2-inch clearance between bottom of fabric and finish grade.

B. Stake locations of fence lines, gates, and terminal posts. Do not exceed intervals of 500 feet or line of sight between stakes. Indicate locations of utilities, lawn sprinkler system, underground structures, benchmarks, and property monuments.

3.03 POST SETTING

A. Drill or hand-excavate holes for posts to diameters and spacing indicated, in firm, undisturbed soil. Driven posts are not acceptable. Postholes shall be clear of loose materials. Waste materials from postholes shall be removed from Site or regraded into slopes on Site.

B. Posthole Depth:

1. Minimum 3 feet below finished grade.
2. 2 inches deeper than post embedment depth below finish grade.

C. Set posts with minimum embedment below finished grade of 34 inches and with top rail at proper height above finished grade. Verify posts are set plumb, aligned, and at correct height and spacing. Brace posts, as necessary, to maintain correct position and plumbness until concrete sets.

D. Backfill postholes with concrete to 2 inches above finished grade. Vibrate or tamp concrete for consolidation. Protect above ground portion of posts from concrete splatter.

E. Before concrete sets, crown and finish top of concrete to readily shed water.

F. Terminal Posts: Locate terminal end, corner, and gate posts per ASTM F567 and terminal pull posts at changes in horizontal or vertical alignment of 15 degrees or more.

G. Line Posts: Space line posts uniformly at 10 feet on centers between terminal end, corner, and gate posts.

3.04 POST BRACING

A. Install according to ASTM F567, maintaining plumb position, and alignment of fencing. Install braces at gate, end, pull, and corner posts diagonally to

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adjacent line posts to ensure stability. Install braces on both sides of corner and pull posts.

1. Locate horizontal braces at mid-height of fabric or higher, on fences with top rail, and 2/3-fabric height on fences without top rail. Install so posts are plumb when diagonal truss rod assembly is under proper tension.

3.05 TOP RAILS

A. Install according to ASTM F567, maintaining plumb position and alignment of fencing. Run rail continuously through line post caps and terminating into rail end attached to posts or posts caps fabricated to receive rail at terminal posts. Install top rail sleeves with springs at 105 feet maximum spacing to permit expansion in rail.

3.06 BARBED WIRE SUPPORTING ARMS

A. Barbed wire supporting arms shall be installed as indicated and as recommended by manufacturer. Bolt or rivet supporting arm to top of post in a manner to prevent easy removal with hand tools. Angle single arms to outside of fence.

3.07 TENSION WIRE

A. Install according to ASTM F567 and ASTM F1916, maintaining plumb position and alignment of fencing. Pull wire taut, without sags. Fasten fabric to tension wire with tie wires at a maximum spacing of 24 inches on center.

B. Install tension wire within 6 inches of bottom of fabric and tie to each post with not less than same diameter and type of wire.

3.08 CHAIN LINK FABRIC

A. Do not install fabric until concrete has cured minimum 7 days.

B. Install fabric with twisted and barbed selvage at top.

C. Apply fabric to outside of enclosing framework. Pull fabric taut to provide a smooth and uniform appearance free from sag, without permanently distorting fabric diamond or reducing fabric height. Tie fabric to posts, rails, and tension wires. Anchor to framework so fabric remains under tension after pulling force is released.

D. Splicing shall be accomplished according to ASTM F1916 by weaving a single picket into the ends of the rolls to be joined.

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E. Leave 2 inches between finish grade or surface and bottom selvage, unless otherwise indicated.

F. Tension or Stretcher Bars: Thread through fabric and secure to end, corner, pull, and gate posts with tension bands spaced not more than 15 inches on center.

G. Tie Wires: Fasten ties to wrap a full 360 degrees around rail or post and a minimum of one complete diamond of fabric. Twist ends of tie wire three full twists, and cut off protruding ends to preclude untwisting by hand.

1. Maximum Spacing: Tie fabric to line posts at 12 inches on center and to brace and top rails at 24 inches on center.

3.09 PRIVACY SLATS

A. Install slats in chain link fabric to limits shown on Drawings.

B. Slats shall be installed vertically into locking channel at bottom of chain link fabric as recommended by manufacturer.

3.10 BARBED WIRE

A. Install barbed wire uniformly in configurations of three strands of barbed wire on supporting arms. Pull wire taut and install securely to supporting arms and secure to end terminal post or terminal arms.

3.11 GATES

A. Install gates according to manufacturer’s written instructions, level, plumb and secure for full opening without interference. Attach fabric and hardware to gate using tamper-resistant or concealed means. Adjust hardware for smooth operation and lubricate where necessary so gates operate satisfactorily from open or closed position.

B. Set gate stops in concrete to engage center drop rod or plunger bar.

3.12 GATE OPERATOR SYSTEMS

A. Install gate operator systems in accordance with manufacturer’s recommendations, aligned and true to fence line and grade.

B. Furnish with equipment and accessories necessary for complete installation.

C. Hand excavate holes for pads in firm undisturbed soil to dimensions, depths, and locations as required by gate operator component manufacturer’s written instructions and as shown on the Drawings.

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D. Vehicle Loop Detector System: Cut grooves in pavement and bury and seal wire loop according to manufacturer's written instructions. Connect to equipment operated by detector.

3.13 ELECTRICAL GROUNDING

A. Ground fences at a maximum interval of 1,000 feet in accordance with applicable requirements of IEEE C2, National Electrical Safety Code.

B. Protection at Crossings of Overhead Electrical Power Lines: Ground fence at location of crossing and at a maximum distance of 150 feet on each side of crossing.

C. Protection of fences adjacent to overhead electrical power lines: For locations where the nearest overhead conductor is within five feet horizontally, ground the fence. Provide grounding electrodes at an interval not to exceed 150 feet.

D. Grounding Method: At each grounding location, drive a grounding electrode vertically until top is 6 inches below finished grade. Connect the grounding electrode to fence with No. 6 AWG conductor. Connect conductor to each fence component at grounding location.

3.14 FIELD QUALITY CONTROL

A. Post and Fabric Testing: Test fabric tension and line post rigidity according to ASTM F1916.

B. Gate Tests:

1. Prior to acceptance of installed gates, demonstrate proper operation of gates under each possible open and close condition specified.
2. Adjust gate to operate smoothly, easily, and quietly, free of binding, warp, excessive deflection, distortion, nonalignment, misplacement, disruption, or malfunction, throughout entire operational range.
3. Confirm that latches and locks engage accurately and securely without forcing and binding.

C. Automatic Gate Operator:

1. Energize circuits to electrical equipment and devices.
2. Adjust operators, controls, safety devises, and limit switches.
3. Start units to confirm proper motor rotation and unit operation free of binding. Test and adjust all gate controls for proper operation.
4. Replace damaged and malfunctioning controls and equipment.
5. Lubricate hardware, gate operator and other moving parts.

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3.15 MANUFACTURER'S SERVICES

A. Provide manufacturer's representative at Site in accordance with Section 01 43 33, Manufacturers' Field Services, to train Owner's personnel to adjust, operate, and maintain gates.

3.16 CLEANUP

A. Remove excess fencing materials and other debris from Site.

END OF SECTION

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SECTION 32 91 13
SOIL PREPARATION

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   a. C33/C33M, Standard Specification for Concrete Aggregates.
   b. C602, Standard Specification for Agricultural Liming Materials.
   c. D2974, Standard Test Methods for Moisture, Ash, and Organic Matter of Peat and Other Organic Soils.
   d. D5268, Standard Specification for Topsoil Used for Landscaping Purposes.

1.02 SUBMITTALS

A. Action Submittals:

1. Samples: Representative of stockpiled or imported topsoil.

B. Informational Submittals:

1. Certified Topsoil Analysis Reports:
   a. Indicate quantities of materials necessary to bring onsite or imported topsoil into compliance with textural/gradation requirements.
   b. Indicate quantity of lime, quantity and analysis of fertilizer, and quantity and type of soil additive.
   c. Indicate schedule and method of mixing soil amendments.

1.03 SEQUENCING AND SCHEDULING

A. Perform Work specified in Section 31 10 00, Site Clearing, prior to performing Work specified under this section.

PART 2 PRODUCTS

2.01 TOPSOIL

A. General: Natural, friable, sandy loam, obtained from well-drained areas, free from objects larger than 1-1/2 inches maximum dimension, and free of subsoil, roots, grass, other foreign matter, hazardous or toxic substances, and

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deleterious material that may be harmful to plant growth or may hinder grading, planting, or maintenance.

B. Composition: In general accordance with ASTM D5268:

1. Gravel-Sized Fraction: Maximum **5** percent by weight retained on a No. 10 sieve.
2. Sand-Sized Fraction: Minimum 20 to 60 percent passing No. 10 sieve.
3. Silt and Clay-Sized Fraction: Minimum 35 to 70 percent.

C. Organic Matter: Minimum 1.5 percent by dry weight as determined in accordance with ASTM D2974.

D. pH: Range 5.0 to 7.0.

E. Textural Amendments: Amend as necessary to conform to required composition by incorporating sand, peat, manure, or sawdust.

F. Source: Stockpile material onsite, in accordance with Section 31 10 00, Site Clearing, or import topsoil if onsite material is insufficient in quantity.

2.02 SOURCE QUALITY CONTROL

A. Topsoil Analysis/Testing: Performed by county or state soil testing service or approved certified independent testing laboratory.

PART 3 EXECUTION

3.01 SUBGRADE PREPARATION

A. Scarify subgrade to minimum depth of 6 inches where topsoil is to be placed.

B. Remove stones over 2-1/2 inches in any dimension, sticks, roots, rubbish, and other extraneous material.

C. Limit preparation to areas which will receive topsoil within **2** days after preparation.

3.02 TOPSOIL PLACEMENT

A. Do not place topsoil when subsoil or topsoil is frozen, excessively wet, or otherwise detrimental to the Work.

B. Mix soil amendments, lime, and other soil additives, identified in analysis reports with topsoil before placement or spread on topsoil surface and mix thoroughly into entire depth of topsoil before planting or seeding. Delay mixing of fertilizer if planting or seeding will not occur within 3 days.

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C. Place one-half of the total depth of topsoil and work into top 4 inches of subgrade soil to create a transition layer. Place remainder of topsoil to depth of 6 inches where seeding and planting are scheduled.

D. Uniformly distribute to within 1/2 inch of final grades. Fine grade topsoil eliminating rough or low areas and maintaining levels, profiles, and contours of subgrade.

E. Remove surplus subsoil and topsoil from Site. Grade stockpile area as necessary and place in condition acceptable for planting or seeding.

END OF SECTION

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SECTION 33 05 01
CONVEYANCE PIPING—GENERAL

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Concrete Institute (ACI): 301, Specifications for Structural Concrete.
2. American Water Works Association (AWWA):
   a. C110/A21.10, Ductile-Iron and Gray-Iron Fittings.
   b. C115/A21.15, Flanged Ductile-Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges.
   c. C207, Steel Pipe Flanges for Waterworks Service - Sizes 4 in. Through 144 in. (100 mm Through 3,600 mm).
   d. C210 Liquid-Epoxy Coating Systems for the Interior and Exterior of Steel Water Pipelines.
   e. C213, Fusion-Bonded Epoxy Coating for the Interior and Exterior of Steel Water Pipelines.
   f. C217, Petrolatum and Petroleum Wax Tape Coatings for the Exterior of Connections and Fittings for Steel Water Pipelines.
   g. C219, Bolted, Sleeve-Type Couplings for Plain-End Pipe.
   h. C221, Fabricated Steel Mechanical Slip-Type Expansion Joints.
   i. C606, Grooved and Shouldered Joints.
3. ASTM International (ASTM):
   a. A497/A497M, Standard Specification for Steel Welded Wire Reinforcement, Deformed, for Concrete.
   b. A615/A615M, Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
   c. C94/C94M, Standard Specification for Ready-Mixed Concrete.
   d. C150/C150M, Standard Specification for Portland Cement.
   e. F593, Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
4. NSF International (NSF):
   a. NSF/ANSI 61, Drinking Water System Components - Health Effects.
   b. NSF/ANSI 372, Drinking Water System Components - Lead Content.

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1.02 DESIGN REQUIREMENTS

A. Where pipe class or wall thickness is not indicated, design piping system for maximum stress based on the following test pressure and earth loads:

1. Operating Pressure: 200 psi.
2. Field Hydrostatic Test Pressure: 1.25 times operating pressure.
3. Earth Loads: Varies based on cover.
4. Soil Density: 130 pcf, minimum.
5. Traffic Loads: AASHTO HS20-44 wheel loads.

1.03 SUBMITTALS

A. Action Submittals:

1. Detailed pipe fabrication drawings showing pipe details, special fittings and bends, dimensions, coatings, and other pertinent information.
2. Layout drawing showing location of each pipe section and each special length.
3. Pipe pressure class.
4. Wall thickness, reinforcing, and strength calculations.

B. Informational Submittals: Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements.

1.04 DELIVERY, STORAGE, AND HANDLING

A. In accordance with manufacturer's recommendations.

B. Marking at Plant: Mark each pipe and fitting at plant. Include date of manufacture, manufacturer's identification, specification standard, diameter of pipe, pipe class, pipe number for laying purposes, and other information required for type of pipe.

C. Pipe, specials, and fittings received at Project Site in damaged condition will not be accepted.

D. Gasket Storage: Store rubber gaskets in cool, well ventilated place, and do not expose to direct rays of sun. Do not allow contact with oils, fuels, petroleum, or solvents.

E. Store and support pipe securely to prevent accidental rolling and to avoid contact with mud, water, or other deleterious materials.

F. Handling:

1. Pipe shall be handled with proper equipment in a manner to prevent distortion or damage. Use of hooks, chains, wire ropes, or clamps that

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could damage pipe, damage coating or lining, or kink and bend pipe ends is not permitted.

2. Use heavy canvas, or nylon slings of suitable strength for lifting and supporting materials.
3. Lifting pipe during unloading or lifting into trench shall be done using two slings placed at quarter point of pipe section. Pipe may be lifted using one sling near center of pipe, provided pipe is guided to prevent uncontrolled swinging and no damage will result to pipe or harm to workers. Slings shall bear uniformly against pipe.
4. Pipe and fittings shall not be stored on rocks or gravel, or other hard material that might damage pipe. This includes storage area and along pipe trench.

PART 2 PRODUCTS

2.01 GENERAL

A. Components and Materials in Contact with Water for Human Consumption: Comply with the requirements of the Safe Drinking Water Act and other applicable federal, state, and local requirements. Provide certification by manufacturer or an accredited certification organization recognized by the Authority Having Jurisdiction that components and materials comply with the maximum lead content standard in accordance with NSF/ANSI 61 and NSF/ANSI 372.

1. Use or reuse of components and materials without a traceable certification is prohibited.

2.02 PIPE

A. As specified in the individual specification(s) following this section.

2.03 JOINTS

A. As specified in the individual specification(s) following this section.

2.04 COUPLINGS

A. General:

1. Coupling linings for use in potable water systems shall be in conformance with NSF/ANSI 61.
2. Couplings shall be rated for appropriate operating pressure and hydrostatic test pressure.
3. Exposed, bolted, sleeve-type couplings shall be lined and coated with fusion bonded epoxy in accordance with AWWA C213.

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4. Buried, bolted, sleeve-type couplings shall be lined and coated with liquid epoxy in accordance with AWWA C210 and wrapped with petroleum wax tape in accordance with AWWA C217**.**

B. For Pipe with Plain-Ends:

1. Bolted, sleeve-type coupling, in accordance with AWWA C219.
   a. Manufacturer of couplings shall observe same quality control requirements as specified in AWWA C221 for fabrication of pipe expansion joints.
   b. Unless thrust restraint is provided by other means, bolted, sleeve-type couplings shall be harnessed. Harness details shall be in accordance with requirements of appropriate reference standard or as shown on Drawings.
   c. Certified Welding Inspector at coupling fabrication facility shall verify welders and welding procedures are qualified, procedures are being followed, and quality assurance functions are being implemented.
   d. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements.
2. Fabricated steel, mechanical slip-type expansion joints, in accordance with AWWA C221.
   a. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements.

C. For Pipe with Grooved Ends:

1. Grooved couplings, in accordance with AWWA C606. System shall provide for flexible or rigid joints as shown on Drawings.
2. Exposed couplings shall be lined and coated with liquid epoxy in accordance with AWWA C210**.**
3. Buried couplings shall be lined and coated with coal tar epoxy in accordance with AWWA C210 and wrapped with petroleum wax tape in accordance with AWWA C217**.**

D. For Pipe with Flanged Ends:

1. Flanged coupling adapters, in accordance with AWWA C219.
   a. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements.
2. Dismantling joints for connecting flanged pipe shall be AWWA C219 compliant. Provide studs and nuts to seal gasket separate and independent from tie-bar restraint system.

E. Bolting Materials for Couplings: Stainless steel in accordance with AWWA C219.

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2.05 SERVICE SADDLES

A. Double strap design rated for minimum working pressure/pipe class to which connection is made.

2.06 SLAB, FLOOR, WALL, AND ROOF PENETRATIONS

A. Modular Mechanical Seal:

1. Type: Interconnected synthetic rubber links shaped and sized to continuously fill annular space between pipe and wall sleeve opening.
2. Assemble interconnected rubber links with Type 316 stainless steel bolts, nuts, and pressure plates.
3. Size modular mechanical seals according to manufacturer's instructions for the size of pipes shown to provide a watertight seal between pipe and wall sleeve opening.
4. Manufacturers and Products:
   a. Thunderline/LinkSeal, Div. of PSI, Houston, TX; Link Seal.
   b. Calpico, Inc., South San Francisco, California; Sealing Linx.
   c. Advance Products and Systems, Lafayette, Louisiana; Innerlynx.

B. Wall Sleeves:

1. Diameter, ends, and length shall be as shown on Drawings.
2. Shall include integral seep ring to minimize seepage between metal sleeve and concrete.

C. Wall Couplings:

1. Diameter, ends, and length shall be as shown on Drawings.
2. Wall couplings shall provide flexible mechanical joint.
3. Body and end rings shall be coated with fusion bonded epoxy.
4. Body shall include integral seep ring.
5. Shall comply with AWWA C219.

D. If core drilling is required for penetrations of existing concrete walls or slabs, locations of drilling shall be determined by radiograph to avoid damage to reinforcing steel and conduits.

2.07 FLANGES, FLANGE GASKETS, AND BOLTING MATERIALS

A. As specified in individual specifications following this section.

B. Flanges, bolting materials, and flange gaskets for steel flanges shall conform to AWWA C207.

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C. Flanges, bolting materials, and flange gaskets for ductile iron flanges shall conform to AWWA C110 and AWWA C115.

D. Stainless steel bolting material shall conform to ASTM F593, Type 304 stainless steel, Group 1, Condition SH1, 2, 3 or 4.

2.08 FLANGE INSULATION KITS AND INSULATING COUPLINGS

A. As specified in Section 26 42 01, Pipe Bonding and Test Stations.

2.09 PIPE MARKING TAPE

A. As specified in Section 31 23 23.15, Trench Backfill.

2.10 PIPE BEDDING AND PIPE ZONE MATERIAL

A. As specified in Section 31 23 23.15, Trench Backfill.

2.11 TRENCH STABILIZATION MATERIAL

A. As specified in Section 31 23 23.15, Trench Backfill.

PART 3 EXECUTION

3.01 GENERAL

A. Notify Contractor at least 2 weeks prior to field fabrication of pipe or fittings.

B. Furnish feeler gauges of proper size, type, and shape for use during installation for each type of pipe furnished.

C. Distributing Materials: Place materials along trench only as will be used each day, unless otherwise approved by Contractor. Placement of materials shall not be hazardous to traffic or to general public, obstruct access to adjacent property, or obstruct others working in area.

3.02 EXAMINATION

A. Verify size, material, joint types, elevation, and horizontal location of existing pipeline to be connected to new pipeline or new equipment.

B. Inspect size and location of structure penetrations to verify adequacy of wall pipes, sleeves, and other openings.

C. Damaged Coatings and Linings: Repair using coating and lining materials in accordance with manufacturer’s instructions.

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3.03 PREPARATION OF TRENCH

A. Prepare trench as specified in Section 31 23 16, Excavation.

B. Unless otherwise permitted by Contractor, maximum length of open trench shall not exceed 500 feet.

3.04 INSTALLATION

A. General:

1. Join pipe and fittings in accordance with manufacturer's instructions, unless otherwise shown or specified.
2. Install individual pipe lengths in accordance with approved lay diagram. Misplaced pipe shall be removed and replaced.
3. Inspect pipe and fittings before installation, clean ends thoroughly, remove foreign matter and dirt from inside.
4. Flanged Joints:
    a. Install perpendicular to pipe centerline.
    b. Bolt Holes: Straddle vertical centerline, aligned with connecting equipment flanges or as shown on Drawings.
    c. Use torque-limiting wrenches to provide uniform bearing and proper bolt tightness.
    d. Flange Type: Use flat-faced flange when joining with flat-faced ductile or cast iron flange.
5. Couplings:
    a. Install in accordance with manufacturer's written instructions.
    b. Before coupling, clean pipe holdback area of oil, scale, rust, and dirt.
    c. Do not remove pipe coating. If damaged, repair before joint is made.
    d. Clean gaskets before installation.
    e. If necessary, lubricate with gasket lubricant for installation on pipe ends.
    f. Tighten coupling bolts progressively, drawing up bolts on opposite sides gradually until bolts have uniform tightness.

B. Buried Pressure Pipe:

1. Concrete Encased or Embedded Pipe: Do not encase joints in concrete, unless specifically shown on Drawings.
2. Placement:
    a. Keep trench dry until pipe laying and joining is completed.
    b. Exercise care when lowering pipe into trench to prevent twisting or damage to pipe.
    c. Measure for grade at pipe invert, not at top of pipe.

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d. Excavate trench bottom and sides of ample dimensions to permit proper joining, welding, visual inspection, and testing of entire joint.
e. Prevent foreign material from entering pipe during placement.
f. Close and block open end of last laid pipe section when placement operations are not in progress and at close of day's work.
g. In general, lay pipe upgrade with bell ends pointing in direction of laying.
h. Deflect pipe at joints for pipelines laid on a curve using unsymmetrical closure of spigot into bell. If joint deflection of standard pipe lengths will not accommodate horizontal or vertical curves in alignment, provide:
    1) Shorter pipe lengths.
    2) Special mitered joints.
    3) Standard or special fabricated bends.
i. Check gasket position with feeler gauge to assure proper seating.
j. After joint has been made, check pipe alignment and grade.
k. Place sufficient pipe zone material to secure pipe from movement before next joint is installed.
l. Prevent uplift and floating of pipe prior to backfilling.

3. Tolerances:
    a. Deflection From Horizontal Line: Maximum 2 inches.
    b. Deflection From Vertical Line: Maximum 1 inch(es).
    c. Joint Deflection: Maximum of 75 percent of manufacturer's recommendation.
    d. Horizontal position of pipe centerline on alignment around curves maximum variation of 1 foot from position shown.
4. Cover Over Top of Pipe: Minimum 4 feet, unless otherwise shown.
5. Disposal of Excess Excavated Material: As specified in Section 31 23 16, Excavation.

3.05 THRUST RESTRAINT

A. Location: At pipeline tees, plugs, caps, bends, and locations where unbalanced forces exist.

3.06 CORROSION PROTECTION

A. Buried Pipe: As specified in the individual specifications following this section.

B. Notify Contractor at least 3 days prior to start of surface preparation, coating application, and corrosion protection work.

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3.07 PLACEMENT OF PIPE MARKING TAPE

A. Place pipe locating tape in accordance with Section 31 23 23.15, Trench Backfill.

3.08 PIPE BEDDING AND ZONE MATERIAL

A. Place pipe bedding and pipe zone material in accordance with Section 31 23 23.15, Trench Backfill.

3.09 FIELD QUALITY CONTROL

A. Pressure Leakage Testing: As specified in the individual specification(s) following this section.

3.10 CLEANING AND DISINFECTION

A. Following assembly and testing, and prior to disinfection and final acceptance, flush pipelines with water at 2.5 fps minimum flushing velocity until foreign matter is removed. Dispose of water and flushed foreign matter.

B. If impractical to flush large diameter pipe at 2.5 fps, clean pipe in-place from inside by brushing and sweeping, then flush or blow line at lower velocity.

C. Remove accumulated debris through blowoffs 2 inches and larger or by removing spools and valves from piping.

D. Disinfection shall be in accordance with NMED regulations.

END OF SECTION

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SECTION 33 05 01.02
DUCTILE IRON PIPE AND FITTINGS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards that may be referenced in this section:

1. American Association of State Highway and Transportation Officials (AASHTO): T99, Standard Method of Test for the Moisture-Density Relations of Soils Using a 2.5-kg (5.5-lb) Rammer and a 305-mm (12-in.) Drop.
2. American Society of Mechanical Engineers (ASME):
   a. B16.21, Nonmetallic Flat Gaskets for Pipe Flanges.
   b. B16.42, Ductile Iron Pipe Flanges and Flanged Fittings Classes 150 and 300.
3. American Water Works Association (AWWA):
   a. C104/A21.4, Cement-Mortar Lining for Ductile-Iron Pipe and Fittings.
   b. C105/A21.5, Polyethylene Encasement for Ductile-Iron Pipe Systems.
   c. C110/A21.10, Ductile-Iron and Gray-Iron Fittings.
   d. C111/A21.11, Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
   e. C115/A21.15, Flanged Ductile-Iron Pipe with Ductile-Iron or Gray-Iron Fittings.
   f. C116/A21.16, Protective Fusion-Bonded Epoxy Coatings for the Interior and Exterior Surfaces of Ductile-Iron and Gray-Iron Fittings for Water Supply Service.
   g. C150/A21.50, Thickness Design of Ductile-Iron Pipe.
   h. C151/A21.51, Ductile-Iron Pipe. Centrifugally Cast, for Water.
   i. C153/A21.53, Ductile-Iron Compact Fittings for Water Service.
   j. C600, Installation of Ductile-Iron Water Mains and Their Appurtenances.
   k. C606, Grooved and Shouldered Joints.
4. ASTM International (ASTM):
   a. A307, Standard Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength.
   b. A563, Standard Specification for Carbons and Alloy Steel Nuts.
   c. D882, Standard Test Method for Tensile Properties of Thin Plastic Sheeting.
   d. D1330, Standard Specification for Rubber Sheet Gaskets.
   e. D1922, Standard Test Method for Propagation Tear Resistance of Plastic Film and Thin Sheeting by Pendulum Method.

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f. D2000, Standard Classification System for Rubber Products in Automotive Applications.
g. D4976, Standard Specification for Polyethylene Plastics Molding and Extrusion Materials.

5. International Organization for Standardization (ISO): 9001, Quality Management Systems – Requirements.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings: Marking plan and details of standard pipe section showing dimensions, pipe joints, fitting and special fitting pressure rating and thickness, size, coating and lining data.

B. Informational Submittals:

1. Manufacturer's Certificate of Compliance, in accordance with Section 04 43 33, Manufacturers' Field Services, stating that inspections and specified tests have been made and that results thereby comply with requirements of Article Source Quality Control.
2. Manufacturer's certification that materials are in compliance with NSF/ANSI 61 and 372 if applicable.
3. Manufacturer shall furnish sworn certificates that fittings have been manufactured, tested, and inspected in accordance with this and all applicable Specifications.
4. Field Hydrostatic Testing Plan: Submit at least 15 days prior to testing and at minimum, include the following:
   a. Testing dates.
   b. Piping systems and section(s) to be tested.
   c. Method of isolation.
   d. Method of conveying water from source to system being tested.
   e. Calculation of maximum allowable leakage for piping section(s) to be tested.
5. Certifications of Calibration: Approved testing laboratory certificate if pressure gauge for hydrostatic test has been previously used. If pressure gauge is new, no certificate is required.
6. Test documentation form and results.

1.03 QUALITY ASSURANCE

A. Pipe manufacturer shall be ISO 9001 registered.

B. Furnish manufacturer's affidavit of compliance that products are in compliance with NSF/ANSI 61 and 372 when applicable.

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C. Furnish manufacturer's affidavit of compliance to the requirements of AWWA C151 and this section.

PART 2 PRODUCTS

2.01 GENERAL

A. Components and Materials in Contract with Water for Human Consumption:

1. Comply with the requirements of the Safe Drinking Water Act and other applicable federal, state, and local requirements. Provide certification by manufacturer or an accredited certification organization recognized by the Authority Having Jurisdiction that components and materials comply with:
   a. NSF/ANSI 61.
   b. A weighted average lead content of 0.25 percent as determined by NSF/ANSI 372.
2. Use or reuse components and materials without a traceable certification is prohibited.

B. Acceptable Product Markings: NSF-61 and NSF-372 (or NSF-61-G) or other accepted certifier marks demonstrating third party certification with these requirements.

C. Products shall be certified compliant with these requirements by an ANSI accredited certification organization.

2.02 MATERIALS

A. General:

1. Ductile iron pipe and fittings shall be manufactured, lined, coated, and tested domestically in the United States of America.
2. Pipe manufacturer shall certify source manufacturing facility has been producing ductile iron pipe of the specified diameters, pressure, dimensions and standards for a period of not less than 10 years.
3. Ductile iron pipe and fitting shall be supplied by a single manufacturer: Mixing of components and sources is not permitted.

B. Pipe:

1. General:
   a. Pipe shall be new and recently manufactured. Refurbished pipe shall not be provided.
   b. Lined and coated as specified.
2. Meet requirements of AWWA C150/A2.50, AWWA C151/A21.51, and AWWA C111/A21.11.

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3. Centrifugally cast, grade 60-42-10 iron.
4. Pressure rating of pipe shall be 200 psi or as shown on Drawings.
5. Pipe wall thickness of threaded pipe for a flanged pipe end shall be minimum special thickness Class 53 from 12-inch to 54-inch diameter pipe in accordance with AWWA C115/A21.15.
6. Grooved end pipe shall be a minimum Special Class 53.

C. Joints:

1. Mechanical Wedge Action Type Joint:
   a. Use only in areas where adjoining to fixed points where laying length is determined in field.
   b. Prior to purchase and installation, type and application of this joint shall be approved by Contractor.
2. Use of set screws for restraint or field-lock gaskets shall not be allowed.

D. Fittings:

1. Fittings shall be new and recently manufactured. Refurbished fittings will not be accepted.
2. Fittings shall have pressure class ratings equivalent to adjoining pipe at a minimum. Higher pressure rated flanges as required to mate with valves or equipment when equipment or valve flange is of higher pressure than required for piping.
3. Mechanical Joint: In accordance with the following table:

Minimum Pressure Ratings for AWWA C110/A21.10 and C115/A21.15 Ductile Iron Fittings		
Diameter (inches)	**Rubber Gasket Joints (Push-on, Mechanical, Restrained) (psi)**	**Flanged Joints (psi)**
3 to 24	350	250

4. Rubber Gasket Joints Including Mechanical Joints: In accordance with AWWA C111/A21.11 or ASME B16.42**.**
5. Mechanical Joint Fittings: In accordance with AWWA C110/A21.10 and AWWA C153/A21.53.

E. Lining: Fittings shall be cement-lined and asphaltic seal coated in accordance with AWWA C104/A21.4.

F. Coating: Asphaltic type, 1 mil thick, in accordance with AWWA C151/A21.51, AWWA C115/A21.15, AWWA C110/A21.10, and AWWA C153/A21.53.

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G. Polyethylene Encasement:

1. Virgin polyethylene raw material conforming to requirements of ASTM D4976.
2. Elongation: 800 percent, minimum, in machine and transverse direction (ASTM D882).
3. Tensile Strength: 3,600 psi, minimum.
4. Dielectric Strength: 800V per mil-thickness, minimum.
5. Propagation Tear Resistance: 2,550-gram force (gf), minimum, in machine and transverse direction (ASTM D1922).
6. Tube Form: Conform to AWWA C105/A21.5.
7. Film: 0.008 inch (8 mil) thick, minimum.
8. Number of Film Layers: One.

H. Bolting: Grooved End Connections Bolts: Manufacturer's standard.

I. Gaskets:

1. Flat Faced Flange Gaskets:
   a. Pipe Smaller Than 54 Inches: Rated for working pressure 150 psi to 250 psi, 1/8 inch thick, red rubber (SBR), hardness 80 (Shore A), rated to 200 degrees F, conforming to ASME B16.21, AWWA C207, and ASTM D1330, Grade 1 and Grade 2.
2. Grooved End Joint Gaskets: Halogenated butyl, conforming to ASTM D2000 and AWWA C606.

2.03 SOURCE QUALITY CONTROL

A. Factory Tests: In accordance with AWWA C151.

PART 3 EXECUTION

3.01 GENERAL

A. Notify Contractor at least 2 weeks prior to fabrication of pipe and fittings.

3.02 EXAMINATION

A. Inspect pipe and fittings to ensure no cracked, broken, or otherwise defective materials are being used.

3.03 PREPARATION

A. Trench Grade:

1. When specified, grade bottom of trench by hand to specified line and grade with proper allowance for pipe thickness and pipe base. Trench

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bottom shall form a continuous and uniform bearing and support for pipe between bell holes.

2. Before laying each section of pipe, check grade and correct irregularities found. Grade may be disturbed for removal of lifting tackle.

B. Pipe Bedding: Place and compact pipe bedding in accordance with Section 31 23 23.15, Trench Backfill.

C. Bell (Joint) Holes: At each joint, dig bell holes of ample dimensions in bottom of trench, and at sides where necessary, to permit joint to be made properly and to permit easy visual inspection of entire joint.

3.04 INSTALLATION

A. General:

1. Provide and use proper implements, tools, and facilities for safe and proper prosecution of the Work.
2. Lower pipe, fittings, and appurtenances into trench, piece by piece, by means of a crane, slings, or other suitable tools and equipment, in such a manner as to prevent damage to pipe materials, protective coatings and linings.
3. Do not drop or dump pipe materials into trench.

B. Cleaning Pipe and Fittings:

1. Remove lumps, blisters, and excess coal tar coating from bell and spigot ends of each pipe. Wire brush outside of spigot and inside of bell and wipe clean, dry, and free from oil and grease before pipe is laid.
2. Wipe ends of mechanical joint pipe and fittings clean of dirt, grease, and foreign matter.

C. Laying Pipe:

1. Direction of Laying: Lay pipe with bell end facing in direction of laying. For lines on an appreciable slope, face bells upgrade at discretion of Contractor.
2. Mechanical Joint: After first length of pipe is installed in trench, secure pipe in place with approved backfill materials temped under and along sided to prevent movement. Keep ends clear of backfill. After each section is joined, place backfill as specified to prevent movement.
3. Take precautions necessary to prevent floating of pipe prior to completion of backfill operation.
4. When using moveable trench shield, take necessary precautions to prevent pipe joints from pulling apart when moving shield ahead.
5. Do not allow foreign material to enter pipe while it is being placed in trench.

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6. Close and block open end of last laid section of pipe to prevent entry of foreign material, at close of day's work, or whenever workers are absent from job.

D. Joining Mechanical Joint Fittings:

1. Join pipe with mechanical joint fittings in accordance with manufacturer's recommendations.
2. Provide special tools and devices, such as, special jacks, chokers, and similar items required for installation.
3. Lubricate pipe gaskets using lubricant furnished by pipe manufacturer. No substitutes will be permitted.
4. Clean ends of fittings of dirt, mud, and foreign matter by washing with water and scrubbing with a wire brush, after which, slip gland and gasket on plain end of pipe. If necessary, lubricate end of pipe to facilitate sliding gasket in place, then guide fitting onto spigot of pipe previously laid.

E. Cutting Pipe:

1. General: Cut pipe for inserting valves, fittings, or closure pieces in a neat and workmanlike manner without damaging pipe or lining and so as to leave a smooth end, at right angles to axis of pipe.
2. Pipe: Cut pipe with milling type cutter or saw. Do not flame cut.
3. Dressing Cut Ends: Dress cut end of mechanical joint pipe to remove sharp edges or projections, which may damage rubber gasket. Dress cut ends of push-on joint pipe by beveling, as recommended by manufacturer.

F. Field Welding:

1. Use of field welded outlets will not be allowed. Welding for outlets shall be performed only in pipe manufacturer's shop.
2. Field installed outlets may be installed with saddle approved by Engineer. Opening in pipe shall be machined cut and not with cutting torch.

G. Alignment and Grade:

1. Minimum Pipe Cover: 3 feet, unless otherwise indicated on the Drawings.
2. No high points will be allowed between air valves.
3. Maintain pipe grade between invert elevations to provide minimum clearance at air valve locations of 4 feet from existing ground surface to top of pipe.

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4. Install air valves as shown and field verify intervening low points. When field conditions warrant, exceptions may be made upon approval of Contractor.
5. Deviations exceeding 6 inches from specified line or 1 inch from specified grade will not be allowed without express approval of Contractor.
6. Pipeline sections that are not installed to elevations shown or installed as approved by Contractor shall be reinstalled to proper elevation.

H. Thrust Restraint: Restrained joints. Use of thrust blocking will not be allowed.

I. Backfill for Pipe Zone: In accordance with Section 31 23 23.15, Trench Backfill.

J. Polyethylene Encasement:

1. Encase pipe, fittings, and valves where specified in accordance with AWWA C105/A21.5, Method A.
2. Cut polyethylene tube approximately 2 feet longer than pipe length.
3. Slip tube around pipe, centering to provide 1-foot overlap on each adjacent section.
4. Pull encasement to take out slack and wrap snug around pipe.
5. Secure overlap in place and fold at quarter points of pipe length.
6. Wrap and tape encasement snug around fittings and valves.

K. Cathodic Protection, Joint Bonding, and Test Stations:

1. Joint bonds and test stations shall conform to Section 26 42 01, Pipe Bonding and Test Stations.

3.05 HYDROSTATIC TESTING

A. General:

1. Notify Contractor in writing 10 days in advance of testing. Perform testing in presence of Contractor.
2. Test newly installed pipelines. Using water as test medium, pipes shall successfully pass a leakage test prior to acceptance.
3. Furnish testing equipment and perform tests in manner satisfactory to Engineer. Testing equipment shall provide observable and accurate measurements of leakage under specified conditions.
4. Isolate new pipelines that are connected to existing pipelines.
5. Conduct tests on entire pipeline after trench has been backfilled. Testing may be done prior to placement of asphaltic concrete or roadway structural section.
6. Contractor may, if field conditions permit and as determined by Engineer, partially backfill trench and leave joints open for inspection

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and conduct an initial service leak test. Hydrostatic test shall not, however, be conducted until backfilling has been completed.

7. Supply of temporary water shall be as stated in Section 01 50 00, Temporary Facilities and Controls.
8. Dispose of water used in testing.

B. Procedure:

1. Maximum filling velocity shall not exceed 0.25 foot per second, calculated based on the full area of pipe.
2. Expel air from pipe system during filling. Expel air through air release valve or through corporation stop installed at high points and other strategic points.
3. Test pressure shall be as shown on Drawings or 125 percent of system operating pressure based on pressure as measured at low point of pipeline.
4. Apply and maintain specified test pressure with hydraulic force pump. Valve off piping system when test pressure is reached.
5. Maintain hydrostatic test pressure continuously for 2 hours minimum, adding additional make-up water only as necessary to restore test pressure. Test pressure may not fluctuate more than 5 psi.
6. Determine actual leakage by measuring quantity of water necessary to maintain specified test pressure for duration of test.
7. If measured leakage exceeds allowable leakage or if leaks are visible, repair defective pipe section and repeat hydrostatic test.
8. Allowable Leakage: Maximum allowable leakage shall not exceed amount stated in AWWA C600.

END OF SECTION

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SECTION 33 05 01.09
POLYVINYL CHLORIDE (PVC) PRESSURE PIPE AND FITTINGS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Water Works Association (AWWA):
   a. C110, Ductile-Iron and Gray-Iron Fittings.
   b. C153, Ductile-Iron Compact Fittings, for Water Service.
   c. C605, Underground Installation of Polyvinyl Chloride (PVC) and Molecularly Oriented Polyvinyl Chloride (PVCO) Pressure Pipe and Fittings.
   d. C900, Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 4 Inches Through 12 Inches (100 mm Through 300 mm), for Water Transmission and Distribution.
   e. C905, Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 14 Inches through 48 Inches (350 mm through 1,200 mm) for Water Transmission and Distribution.
   f. C907, Injection-Molded Polyvinyl Chloride (PVC) Pressure Fittings, 4 Inches through 12 Inches (100 mm Through 300 mm), for Water, Wastewater, and Reclaimed Water Service.
2. ASTM International (ASTM):
   a. D2241, Standard Specification for Poly(Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series).
   b. D2321, Standard Practice for Underground Installation of Thermoplastic Pipe for Sewers and Other Gravity-Flow Applications.
   c. D2466, Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.
   d. D2467, Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
   e. D2672, Standard Specification for Joints for IPS PVC Pipe Using Solvent Cement.
   f. D2855, Standard Practice for Making Solvent-Cemented Joints with Poly(Vinyl Chloride) (PVC) Pipe and Fittings.
   g. D3139, Standard Specification for Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals.
3. NSF International (NSF).

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1.02 SUBMITTALS

A. Action Submittals: Drawings and material sheets showing pipe diameter, pipe class, dimension ratio (DR), product details, and fitting details.

B. Informational Submittals:

1. Manufacturer's Certificate of Compliance, in accordance with Section 01 43 33, Manufacturers' Field Services.
2. Hydrostatic Testing Plan: Submit at least 15 days prior to testing and at minimum, include the following:
    a. Testing dates.
    b. Piping systems and section(s) to be tested.
    c. Method of isolation.
    d. Method of conveying water from source to system being tested.
    e. Calculation of maximum allowable leakage for piping section(s) to be tested.
3. Certification of Calibration: Approved testing laboratory certificate if pressure gauge for hydrostatic test has been previously used. If pressure gauge is new, no certificate is required.
4. Test report documentation.

1.03 DELIVERY, STORAGE, AND HANDLING

A. Solvent Cement: Store in accordance with ASTM D2855.

PART 2 PRODUCTS

2.01 GENERAL

A. Components and Materials in Contract with Water for Human Consumption:

1. Comply with the requirements of the Safe Drinking Water Act and other applicable federal, state, and local requirements. Provide certification by manufacturer or an accredited certification organization recognized by the Authority Having Jurisdiction that components and materials comply with:
    a. NSF/ANSI 61.
    b. A weighted average lead content of 0.25 percent as determined by NSF/ANSI 372.
2. Use or reuse components and materials without a traceable certification is prohibited.

B. Acceptable Product Markings: NSF-61 and NSF-372 (or NSF-61-G) or other accepted certifier marks demonstrating third party certification with these requirements.

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C. Products shall be certified compliant with these requirements by an ANSI accredited certification organization.

2.02 MATERIALS

A. Pipe:

1. PVC, conforming to requirements of AWWA C900 and AWWA C905.
2. DR of 18 as shown on the Drawings**.**
3. Pipe to be used for potable water conveyance shall meet the requirements of NSF 61 and be manufactured from National Sanitation Foundation (NSF) approved compounds**.**

B. Joints:

1. Rubber gasketed.
2. Conform to AWWA C900 and AWWA C905.

C. Fittings: Ductile iron, conforming to AWWA C153 or AWWA C110 and in accordance with Section 33 05 01.02, Ductile Iron Pipe and Fittings and Section 26 42 02, Galvanic Anode Cathodic Protection System.

D. Restrained Joints:

1. Provide pipe restraint, where indicated on Drawings, by system designed specifically for use with PVC pipe using wedges. Do not use systems with set screws, gripper rings, or gripper gaskets.
2. Minimum Pressure Rating: match pressure rating of pipe.

PART 3 EXECUTION

3.01 INSTALLATION

A. In accordance with AWWA Manual 23 and in applicable Section 33 05 01.02, Ductile Iron Pipe and Fittings. More stringent requirement shall apply.

B. Joints:

1. Rubber Gasketed: In accordance with manufacturer’s written instructions.
2. Restrained Joint Systems: In accordance with manufacturer’s written instructions.

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C. Maximum Joint Deflection :

1. 50 percent of manufacturer's recommended values at joints connecting PVC pipe to PVC pipe, or 0.5 degree joint deflection, whichever is less.
2. Deflection not allowed at joints connecting PVC pipe to DIP fittings.

D. No deflection is allowed at push-on joints.

3.02 INSPECTION AND HYDROSTATIC TESTING

A. General:

1. Notify Contractor in writing at least 5 days in advance of testing. Perform testing in presence of Contractor.
2. Using water as test medium, all newly installed pipelines must successfully pass hydrostatic leakage test prior to acceptance.
3. Conduct field hydrostatic test on buried piping after trench has been completely backfilled and compacted. Testing may, as approved by Contractor, be done prior to placement of asphaltic concrete or roadway structural section.
4. Contractor may, if field conditions permit and as approved by Contractor, partially backfill trench and leave joints open for inspection and conduct an initial informal service leak test. Final field hydrostatic test shall not, however, be conducted until backfilling has been completed as specified above.
5. Supply of Temporary Water: In accordance with Section 01 50 00, Temporary Facilities and Controls.
6. Dispose of water used in testing in accordance with federal, state, and local requirements.
7. Install temporary restraint as necessary to prevent movement of pipe and protect adjacent piping or equipment. Make necessary taps in piping prior to testing.
8. Prior to test, remove or suitably isolate appurtenant instruments or devices that could be damaged by pressure testing.
9. New Piping Connected to Existing Piping:
    a. Isolate new piping with grooved-end pipe caps, blind flanges, or other means as acceptable to Contractor.

B. Hydrostatic Testing Procedure:

1. Furnish testing equipment, as approved by Contractor, which provides observable and accurate measurements of leakage under specified conditions.
2. Maximum Filling Velocity: 0.25 foot per second calculated based on full area of pipe.
3. Expel air from piping system during filling.

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4. Test Pressure: shall be as shown on Drawings or 125 percent of system operating pressure based on pressure as measured at low point of pipeline.
5. Apply and maintain specified test pressure with hydraulic force pump. Valve off piping system when test pressure is reached.
6. Maintain hydrostatic test pressure continuously for 2 hours minimum, adding make-up water only as necessary to restore test pressure to within 5 psi of specified hydrostatic test pressure.
7. Determine actual leakage by measuring quantity of water necessary to maintain specified test pressure for duration of test.

C. Maximum Allowable Leakage:

$$L = \frac{ND(P)^{1/2}}{7400}$$

where:

L = Allowable leakage, in gallons per hour.
N = Number of joints in tested line.
D = Nominal diameter of pipe, in inches.
P = Average test pressure during leakage test, in pounds per square inch.

END OF SECTION

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SECTION 33 05 13
MANHOLES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards that may be referenced in this section:

1. American Association of State Highway and Transportation Officials (AASHTO): M198, Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants.
2. ASTM International (ASTM):
   a. A36/A36M, Standard Specification for Carbon Structural Steel.
   b. A48/A48M, Standard Specification for Gray Iron Castings.
   c. A123/A123M, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   d. A536, Standard Specification for Ductile Iron Castings.
   e. A615/A615M, Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
   f. B139/B139M, Standard Specification for Phosphor Bronze Rod, Bar, and Shapes.
   g. C14, Standard Specification for Nonreinforced Concrete Sewer, Storm Drain, and Culvert Pipe.
   h. C31/C31M, Standard Practice for Making and Curing Concrete Test Specimens in the Field.
   i. C39/C39M, Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
   j. C150/C150M, Standard Specification for Portland Cement.
   k. C192/C192M, Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory.
   l. C387/C387M, Standard Specification for Packaged, Dry, Combined Materials for Mortar and Concrete.
   m. C443, Standard Specification for Joints for Concrete Pipe and Manholes Using Rubber Gaskets.
   n. C478, Standard Specification for Precast Reinforced Concrete Manhole Sections.
   o. C923, Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes, and Laterals.
   p. C990, Standard Specification for Joints in Concrete Pipe, Manholes, and Precast Box Sections using Preformed Flexible Joint Sealants.
   q. C1311, Standard Specification for Solvent Release Sealants.

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r. C1244, Standard Test Method for Concrete Sewer Manholes by the Negative Air Pressure (Vacuum) Test Prior to Backfill.
s. D698, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft3 (600 kN-m/m3)).
t. D4101, Standard Specification for Propylene Injection and Extrusion Materials.
u. F593, Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
v. F594, Standard Specification for Stainless Steel Nuts.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings including details of construction, reinforcing and joints, anchors, lifting, external straps, erection inserts, and other items cast into members.
2. Product Data:
   a. Concrete mix design.
   b. Manhole frame to structure seals.
   c. Manhole frame to structure anchor bolt.
   d. Rubber gaskets and sealants.
   e. External joint wrap.

B. Informational Submittals:

1. Experience Record:
   a. Precast concrete production capabilities.
   b. Evidence of current PCI plant certification.
2. Certificate of Compliance: Certify admixtures and concrete do not contain calcium chloride.
3. Test Reports:
   a. Precast manufacturer’s concrete test cylinders.
   b. Core compression test.
   c. Absorption test.
4. Certified load test data for precast manhole steps.
5. Manufacturer’s recommended installation instructions.
6. Field quality control report.

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1.03 QUALITY ASSURANCE

A. Manufacturer Qualifications:

1. Precast Concrete and Precast Prestressed Concrete: Product of manufacturer with 3 years' experience producing precast concrete products of quality specified.
2. Precast Plant: PCI certified plant with current certification.

PART 2 PRODUCTS

2.01 GENERAL

A. Materials of Construction and Service Conditions:

1. Screws, Bolts, or Nuts: Type 304 stainless steel conforming to ASTM F593 and ASTM F594.
2. Gaskets: Internal and external seals shall be made of materials that have been proven to be resistant to the following exposures and conditions:
   a. Sanitary sewage.
   b. Corrosion or rotting under wet or dry conditions.
   c. Gaseous environment in sanitary sewers and at road surfaces including common levels of ozone, carbon monoxide, and other trace gases at installation site.
   d. Biological environment in soils and sanitary sewers.
   e. Chemical attack by road salts, road oil, and common street spillages or solvents used in street construction or maintenance.
   f. Temperature ranges, variations, and gradients in construction area.
   g. Variations in moisture conditions and humidity.
   h. Fatigue failure caused by a minimum of 30 freeze-thaw cycles per year.
   i. Vibrations because of traffic loading.
   j. Fatigue failure because of repeated variations of tensile, compressive and shear stresses, and repeated elongation and compression. Material shall remain flexible allowing repeated movement.
3. Materials shall be compatible with each other and manhole materials.
4. Designed to provide a 20-year service life.

B. Structures shall meet requirements of ASTM C478, this specification and the following:

1. Concrete:
   a. Cement: Meet requirements of ASTM C150/C150M.

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b. Compressive Strength:
   1) Minimum 4,000 psi.
   2) Minimum strength shall be confirmed at 7 days by making two standard cylinders per manhole for testing.
c. Concrete mix design shall include Xypex C-500 or C-1000 based upon mix design at dosage recommended by manufacturer for installation.

2. Reinforcement: Grade 60, unless otherwise specified.
3. Ring: Custom made with openings to meet indicated pipe alignment conditions and invert elevations.
4. Floor: Minimum 6 inches below pipe to provide clearance for grouting channels.
5. Joint:
   a. Form joint contact services with machined castings.
   b. Surfaces shall be parallel with nominal 1/16-inch clearing and tongue equipped with recess for installation of O-ring rubber gasket.
6. Gasket: Meet requirements of ASTM C443.

2.02 PRECAST MANHOLES

A. Riser Sections:

1. Fabricate in accordance with ASTM C478.
2. Diameter: Minimum 48 inches or as shown on the Drawings.
3. Wall Thickness: Minimum 4 inches or 1/12 times inside diameter, whichever is greater.
4. Top and bottom surfaces shall be parallel.
5. Joints: Tongue-and-groove and confined O-ring with rubber gaskets meeting ASTM C443.

B. Cone Sections:

1. Eccentric or as shown on Drawings.
2. Same wall thickness and reinforcement as riser section.
3. Top and bottom surfaces shall be parallel.

C. Base Sections and Base Slab:

1. Base slab integral with sidewalls.
2. Fabricate in accordance with ASTM C478.

D. Manhole Extensions:

1. Concrete grade rings; maximum 6 inches high.
2. Fabricate in accordance with ASTM C478.

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E. Joint Seal Manufacturers and Products:

1. Butyl Gaskets:
   a. Hamilton Kent, Sparks, NV; Kent-Seal No. 2.
   b. Henry Company, Houston, TX; Ram-Nek.
   c. Trelleborg Engineered Solutions, Park Hills, MO; NPC Bidco C-56.
2. Confined Plastic or Rubber O-Ring:
   a. As recommended by precasting manufacturer.
   b. Meet requirements of ASTM C443.
3. External Wrap:
   a. Sealing Systems, Inc., Loretto, MN; Gator Wrap.
   b. Henry Company, Houston, TX; RU116 Rubr-Nek External Joint Wrap.
   c. Trelleborg Engineered Solutions, Park Hills, MO; NPC External Joint Wrap.
   d. Cretex Specialty Products, Waukesha, WI; Cretex Wrap.

F. Polypropylene Steps:

1. Fabricate from minimum 1/2 inch, Grade 60, steel bar meeting ASTM A615/A615M.
2. Polypropylene encasement shall conform to ASTM D4101.
3. Minimum Width: 13 inches, center-to-center of legs.
4. Embedment: 3-1/2-inch minimum and 4-1/2-inch minimum projection from face of concrete at point of embedment to center of step.
5. Cast in manhole sections by manufacturer.
6. Load Test: Capable of withstanding ASTM C478 vertical and horizontal load tests.

2.03 CAST-IN-PLACE MANHOLES

A. Concrete: As specified in Section 03 30 00, Cast-in-Place Concrete.

B. Reinforcing Steel: As specified in Section 03 21 00, Reinforcing Steel.

2.04 MANHOLE FRAMES AND COVER

A. Castings:

1. Tough, close-grained gray iron, sound, smooth, clean, free from blisters, blowholes, shrinkage, cold shuts, and defects.
2. Cast Iron: ASTM A48/A48M Class 30B.

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3. Ductile Iron: ASTM A536, Grade 60-40-12.
4. Plane or grind bearing surfaces to ensure flat, true surfaces.

B. Cover: See Detail 3305-725.

2.05 MANHOLE FRAME CONNECTION TO STRUCTURE

A. Butyl Sealant:

1. Conform to ASTM C1311, or AASHTO M198 and ASTM C990.
2. Trowelable or cartridge applied.
3. Manufacturers and Products:
   a. Tremco Commercial Sealants and Waterproofing, Beachwood, OH; Tremco Butyl Sealant.
   b. Bostik, Middleton, MA; Chem-Calk 300.
   c. Press-Seal Gasket Company, Fort Wayne, IN; EZ-Stik #3.

B. External Wrap:

1. Meet requirements of ASTM C923.
2. Construct of high quality rubber that will provide flexible watertight seal around joint.
3. Thickness: Minimum 60 mils.
4. Consist of a top and bottom section and be sealed to structure, frame top, and bottom with mastic as applicable.
5. Length: Extend from manhole frame and extension ring to cone section.
6. Bands: If required, constructed of minimum 16-gauge sheet if channeled, or 5/16-inch diameter if round.
7. Manufacturers and Products:
   a. Sealing Systems, Inc., Loretto, MN; Infi-Shield.
   b. Trelleborg Engineered Systems, Milford, NH; NPC Flexrib Frame-Chimney Seals.
   c. Cretex Specialty Products, Waukesha, WI; X-85 Seal.

C. Internal Wrap or Sealing Membrane:

1. Meet requirements of ASTM C923.
2. Minimum internal thickness of 3/16 inch or as recommended by manufacturer for installation climate.
3. Designed for application and have a demonstrated history of accommodating differential expansion between frame and concrete.
4. Width: Minimum 8 inches.
5. Expansive type wraps shall be fabricated of high quality rubber or urethane.
6. Bands: If required, constructed of minimum 16-gauge sheet if channeled, or 5/16-inch diameter if round.

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7. Wrap shall not restrict access to manhole.
8. Manufacturers and Products:
    a. Sealing Systems, Inc., Loretto, MN; Flex-Seal Utility Sealant.
    b. Trelleborg Engineered Systems, Milford, NH; NPC Flexrib Frame-Chimney Seals.
    c. Cretex Specialty Products, Waukesha, WI; Internal Manhole Chimney Seal.

D. Frame to Structure Anchor Bolts:

1. 3/4-inch-diameter HAS stainless steel bolts; minimum 6-5/8-inch embedment.

2. Manufacturer and Product: Hilti; HVA Capsules Adhesive Anchoring System.

2.06 MORTAR

A. Standard premixed in accordance with ASTM C387/C387M, or proportion one part Portland cement to two parts clean, well-graded sand that will pass a 1/8-inch screen.

B. Admixtures: May be included; do not exceed the following percentages of weight of cement:

1. Hydrated Lime: 10 percent.
2. Diatomaceous Earth or Other Inert Material: 5 percent.

C. Mix Consistency:

1. Tongue-and-Groove Type Joint: Such that mortar will readily adhere to pipe.
2. Confined Groove (Keylock) Joint: Such that excess mortar will be forced out of groove and support is not provided for section being placed.

2.07 BACKFILL AROUND AND UNDER MANHOLE

A. Structural fill as specified in Section 31 23 23, Fill and Backfill.

2.08 FLEXIBLE JOINTS FOR SEALING PIPES IN MANHOLE

A. Manufacturers and Products:

1. NPC, Inc., Milford, New Hampshire; Kor-N-Seal flexible rubber boot with stainless steel accessories.

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2. A-LOK Products, Inc., Tullytown, PA; Z-LOK XP or A-LOK flexible connectors.

B. Doghouse Manhole/Manhole Over Existing Pipe (where use of a boot is not possible): Green Streak; hydrophilic waterstop CJ-0725-3k.

2.09 SOURCE QUALITY CONTROL

A. Prior to delivery of precast manhole sections to Site, yard permeability tests may be required at point of manufacture. Contractor or Owner will select precast sections not to exceed 10 percent of the total project quantity to test from material which is to be supplied to Project. Test specimens shall be mat tested and meet permeability test requirements of ASTM C14.

B. Concrete Testing: Test two concrete test cylinders for each manhole. Compressive strength shall be tested in accordance with ASTM C31/C31M, ASTM C39/C39M, and ASTM C192/C192M.

C. Inspection:

1. Material Quality:
   a. Manufacturing process and finished sections shall be subject to inspection and approval by Owner and Contractor.
      1) Inspections may take place at manufacturer's plant, at Site after delivery, or at both.
      2) Sections not meeting requirements of this Specification or that are determined to have defects which may affect durability of structure are subject to rejection.
      3) Sections rejected after delivery shall be removed and replaced.
      4) Sections damaged after delivery will be rejected and if already installed shall be repaired to satisfaction of Owner and Contractor.
      5) If structure cannot be repaired it shall be removed and replaced entirely at Contractor's expense.
2. At the time of inspection the sections will be carefully examined for compliance with ASTM C478 and with manufacturer's drawings. Sections will be inspected for general appearance, dimensions, scratch strength, blisters, cracks, roughness, and soundness. Surface shall be dense and close textured.
3. Imperfections may be repaired, subject to approval of Contractor, after demonstration by manufacturer that strong and permanent repairs result.

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PART 3 EXECUTION

3.01 GENERAL

A. Prior to installation inspect materials:

1. Sections not meeting requirements of this specification or that are determined to have defects which may affect durability of structure are subject to rejection.
2. Sections damaged after delivery will be rejected and if already installed shall be repaired to satisfaction of Owner and Contractor.
3. Remove and replace structure that cannot be repaired.

B. If needed, dewater excavation during construction and testing operations.

3.02 EXCAVATION AND BACKFILL

A. Excavation: As specified in Section 31 23 16, Excavation.

B. Backfill: As specified in Section 31 23 23, Fill and Backfill.

3.03 INSTALLATION OF PRECAST MANHOLES

A. Concrete Base:

1. Precast:
   a. Place on compacted structural fill.
   b. Properly locate, ensure firm bearing throughout, and plumb first section.
2. Cast-in-Place:
   a. Invert: Minimum 8 inches below lowest connecting pipe.
   b. First section of manhole shall be cast in concrete base.

B. Sections:

1. Inspect precast manhole sections to be joined.
2. Clean ends of sections to be joined.
3. Do not use sections with chips or cracks in tongue.
4. Locate precast steps in line with each other to provide continuous vertical ladder.

C. Preformed Plastic Gaskets or Rubber O-Ring:

1. Use only pipe primer furnished by gasket manufacturer.
2. Install gasket material in accordance with manufacturer’s instructions.
3. Completed Manhole: Rigid and watertight.

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D. External Joint Wraps: Install in accordance with manufacturer's instructions.

E. Extensions:

1. Provide on manholes in streets or other locations where change in existing grade may be likely.
2. Install to height not exceeding 12 inches.
3. Lay grade rings in mortar with sides plumb and tops level.
4. Seal joints with mortar as specified for sections and make watertight.

3.04 MANHOLE INVERT

A. Construct with smooth transitions to ensure unobstructed flow through manhole. Remove sharp edges or rough sections that tend to obstruct flow.

B. Where full section of pipe is laid through manhole, break out top section and cover exposed edge of pipe completely with mortar. Trowel mortar surfaces smooth.

3.05 MANHOLE FRAMES AND COVERS

A. Install concrete grade rings as required to set covers flush with surface of adjoining pavement or ground surface, unless otherwise shown or directed.

B. Set frames in three equally spaced beads of butyl sealant that run full circumference of frame.

C. Anchor frame to manhole with specified bolts.

D. Install interior manhole frame to structure seals in accordance with manufacturer's instructions. Seal shall cover grade rings.

3.06 CAST-IN-PLACE MANHOLE

A. Concrete: As specified in Section 03 30 00, Cast-in-Place Concrete.

B. Reinforcing Steel: As specified in Section 03 21 00, Reinforcing Steel.

C. Steps:

1. Install manhole steps at 16 inches on center, plus or minus 1/4-inch tolerance, and locate to provide a continuous vertical ladder.
2. Do not vary spacing between any two adjacent steps by more than 1/2 inch.
3. Distance between wall of manhole and center of rung, measured at point of embedment, shall be not less than 4 inches or more than 6-1/4 inches.

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4. Testing:
    a. Test each step for a horizontal pullout load of 400 pounds with load applied over a width of 3-1/2 inches and centered on rung.
    b. Apply load at a uniform rate until required test load is reached.
    c. Provide suitable hydraulic jacks and gauges to perform test.
    d. Steps will be considered acceptable if they remain solidly embedded after application of test load and if no cracking or fracture of step nor spalling of concrete, masonry, or mortar is evident.
    e. Replace, or reset and retest, steps failing to withstand required load.

3.07 MANHOLE PIPING

A. Drop Assembly: See Drawings for detail of installation requirements.

B. Flexible Joints:

1. Provide in pipe not more than 1-1/2 feet from manhole walls.
2. Where last joint of pipe is between 1-1/2 feet and 6 feet from manhole wall, provide flexible joint in manhole wall.

C. Stubouts for Future Connections:

1. Provide same type and class of pipe as specified for use in service connection, lateral, main, or trunk sewer construction. Where there are two different classes of pipe at manhole use higher strength pipe.
2. Grout pipe in precast walls or manhole base to provide watertight seal or use flexible joints as specified herein.
3. Maximum Length: 1-1/2 feet outside manhole wall.
4. Construct invert channels as shown. Unless otherwise approved by Contractor, match inside top elevation of service connection pipe to inside top elevation of outlet pipe.
5. Test Plugs:
    a. Install rubber-gasketed plugs in end of stubouts with gasket joints similar to sewer pipe being used.
    b. Plugs shall withstand internal or external pressures without leakage.
    c. Adequately brace plugs against hydrostatic or air test pressures.

D. Permanent Plugs: Clean interior contact surfaces of pipes to be cut off or abandoned as shown, and construct plug as follows:

1. Pipe 18 Inches or Less in Diameter: Concrete plug in end, minimum 2 feet long.
2. Pipe 20 Inches and Larger: Concrete plug in end, minimum 4 feet long.

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3. Plugs shall be watertight and capable of withstanding internal and external pressures without leakage.

3.08 MANHOLES OVER EXISTING PIPING

A. Maintain flow through existing pipelines at all times.

B. Concrete Pipe: Apply bonding agent on surfaces in contact with concrete.

C. Construct base under existing piping.

D. Construct manhole as detailed in Drawings.

E. Apply minimum of two complete wraps of hydrophilic waterstop centered on pipe in wall.

F. Place a minimum of 24 inches of concrete around each pipe penetration outside manhole against undisturbed soil or compacted aggregate unless otherwise detailed.

G. Grout channel through manhole.

H. Saw cut out or demolish existing pipe within new manhole using method approved by Contractor.

I. Protect new concrete or grout for 7 days after placing concrete.

3.09 CONNECTIONS TO EXISTING MANHOLES

A. Core manhole bases and grouting as necessary.

B. Seal pipe in manhole using flexible connector.

C. Regrout to provide smooth flow into and through manholes.

D. Provide diversion facilities and perform work necessary to maintain flow during connection.

3.10 FIELD QUALITY CONTROL

A. Conduct negative air pressure (vacuum) test on all manholes in accordance with ASTM C1244. Conduct tests in presence of Contractor.

B. Hydrostatic Testing:

1. When, in Contractor’s opinion, groundwater table is too low to permit visual detection of infiltration leaks, hydrostatically test all manholes.

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2. Procedure: Plug inlets and outlets and fill manhole with water to height determined by Contractor.
3. Manhole may be filled 24 hours prior to time of testing, if desired, to permit normal absorption into pipe walls to take place.
4. Leakage in each manhole shall not exceed 0.1 gallon per hour per foot of head above invert.
5. Repair manholes that do not meet leakage test, or do not meet specified requirements from visual inspection.
6. If more than 25 percent of manholes tested fail the hydrostatic test, test all or as many manholes as Contractor deems necessary.

END OF SECTION

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SECTION 33 05 16.13
PRECAST CONCRETE UTILITY STRUCTURE

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards that may be referenced in this section:

1. American Association of State Highway and Transportation Officials (AASHTO): HB-17, Standard Specifications for Highway Bridges, Division 1 Section 3, Division I Design-Loads (Part A, Part B, Part C).
2. ASTM International (ASTM):
   a. A497/A497M, Standard Specification for Steel Welded Wire Reinforcement, Deformed, for Concrete.
   b. A615/A615M, Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
   c. C387/C387M, Standard Specification for Packaged, Dry, Combined Materials for Mortar and Concrete.
   d. C478, Standard Specification for Precast Reinforced Concrete Manhole Sections.
   e. C857, Standard Practice for Minimum Structural Design Loading for Underground Precast Concrete Utility Structures.
   f. C858, Standard Specification for Underground Precast Concrete Utility Structures.
   g. D4101, Standard Specification for Propylene Injection and Extrusion Materials.
3. Occupational Safety and Health Administration (OSHA):
   a. 29 CFR 1910.27, Fixed Ladders.
   b. 29 CFR 1926.502, Fall Protection Systems Criteria and Practices.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Detailed drawings showing complete information for fabrication including, but not limited to:
      1) Member dimensions and cross sections; location, size, and type of reinforcement, including additional reinforcement.
      2) Layout dimensions and identification of each precast unit.
      3) Welded connections indicated by AWS standard symbols.
      4) Details of connections, joints, accessories, and openings or inserts.
      5) Watertight joint details.

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6) Location and details of anchorage devices.
7) Access door details.
8) Details of ladder and pull-up extension.

b. Product Data:
1) Precast concrete items; show materials of construction by ASTM reference and grade.
2) Joint sealants.

B. Informational Submittals:

1. Manufacturer's data for lifting devices for handling and erection.
2. Manufacturer's certification that vault design and manufacture comply with referenced ASTMs (for example, ASTM C857 and ASTM C858).
3. Vault design calculation shall be signed by a civil or structural engineer registered in the State of New Mexico.
4. Manufacturer's laboratory test reports.

1.03 DELIVERY, STORAGE, AND HANDLING

A. Store each unit in a manner that will prevent cracking, distortion, warping, straining and other physical damage, and in a manner to keep marking visible.

B. Lift and support each unit only at designated lifting points and supporting points as shown on Shop Drawings.

PART 2 PRODUCTS

2.01 VAULT MANUFACTURERS

A. Materials, equipment, and accessories specified in this section shall be products of:

1. Oldcastle Precast.
2. Jensen Precast.
3. Hanson Pipe and Precast.

2.02 PRECAST CONCRETE VAULTS

A. Design Requirements:

1. In the event of a conflict between or among standards, the more stringent standard shall govern.
2. Comply with ASTM C858, except as modified herein.
3. Concrete: Conform to the requirements of Section 03 30 10, Reinforced Concrete.

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4. Reinforcing Steel:
    a. Deformed Bars: ASTM A615/A615M, Grade 60.
    b. Welded Wire Fabric: ASTM A497/A497M.
5. Nominal Dimensions: As shown on Drawings.
6. Construction: Rigid type and behave monolithically. Do not use panel-type vaults.
7. Design Loads: As determined by ASTM C857, and by using Site-specific values below.
    a. Unit Weight of Soil: 125 pcf.
    b. Active Earth Pressure Coefficient: 0.32.
    c. Groundwater Level: 38 feet below ground surface.
    d. Live Loads: AASHTO HS20-44 truck loading plus impact.
    e. Designed to avoid flotation with a factor of safety equal to 1.2.
8. Design shall accommodate additional stresses or loads that may be imposed during factory precasting, transporting, erection, and placement.
9. Blockouts for penetrations shall be as shown on Drawings.
10. Sealant:
    a. Nonswelling preformed joint sealants to provide a lasting, watertight bond.
    b. Manufacturer and Product: Henry Company; RAM-NEK.
11. Mortar: Comply with ASTM C387/C387M, Type S or use Type I grout as specified in Section 03 62 00, Nonshrink Grouting.

B. Mark each member or element to indicate location in the structure, top surface, and date of fabrication.

2.03 ACCESSORIES

A. Ladder:

1. Provide vault with galvanized steel ladder. Conform to requirements of Section 05 50 00, Metal Fabrications. Provide with pull-up extension.
2. Meet OSHA 29 CFR 1910.27 and OSHA 29 CFR 1926.502 requirements.

B. Vault Hatches: Manufacturer’s standard. HS-20 load rated, spring-assisted, lockable, galvanized steel access door, size as indicated on Drawings. Conform to requirements of Section 05 50 00, Metal Fabrications.

C. Pipe Connections to Vault: Modular mechanical seal conforming to requirements of Section 33 05 01, Conveyance Piping—General. Grout conforming to requirements of Section 03 62 00, Nonshrink Grouting.

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PART 3 EXECUTION

3.01 GENERAL

A. Possible Settlement: If subgrade is encountered that may require removal to prevent structure settlement, notify Engineer. Engineer will determine depth of over excavation and means of stabilizing subgrade prior to structure installation.

B. Place 6-inch minimum thickness of imported crushed aggregate material on undisturbed earth or modified subgrade; thoroughly compact with a mechanical vibrating or power tamper. Meet requirements of Article Excavation and Backfill.

3.02 EXCAVATION AND BACKFILL

A. Remove and keep water clear from excavation during construction.

B. Excavation: As specified in Section 31 23 16, Excavation.

C. Backfill: As specified in Section 31 23 23, Fill and Backfill, and Section 31 23 23.15, Trench Backfill.

3.03 INSTALLATION

A. Concrete Base:

1. Place on prepared subgrade.
2. Properly locate, ensure firm bearing throughout, and plumb first section.

B. Sections:

1. Carefully inspect precast sections to be joined.
2. Thoroughly clean ends of sections to be joined.
3. Do not use sections with chips or cracks.

C. Joints:

1. Fill joints between precast sections per manufacturer’s recommendation.
2. Joints shall be watertight to prevent entrance of groundwater.
3. Joint Finish: Dry pack interior of joints to provide smooth finish.

D. Setting Precast Vault: Install vault to elevations shown on Drawings. Finish grade of structure top shall be even with surrounding finish grade surface, unless noted otherwise on Drawings.

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E. Watertight construction below grade with no open cracks or spalls. Cracking and defective areas of concrete shall be repaired per requirements of Section 03 30 00, Cast-in-Place Concrete, and Section 03 64 23, Crack Repair Epoxy Injection Grouting.

3.04 PIPE CONNECTION TO VAULT

A. Install products in accordance with manufacturer's instructions. Grout pipe connections flush with interior and exterior walls.

END OF SECTION

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SECTION 33 12 17.01
SURGE CONTROL SYSTEM

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Society of Mechanical Engineers (ASME):
   a. B16.5, Pipe Flanges and Flanged Fittings.
   b. B16.11, Forged Steel Fittings, Socket-Welding and Threaded.
2. National Electrical Manufacturers Association (NEMA): ICS 1, General Standards for Industrial Control and Systems.
3. Steel Structures Painting Council (SSPC):
   a. SP 6, Commercial Blast Cleaning.
   b. SP 10, Near-White Blast Cleaning.

1.02 SUBMITTALS

A. Action Submittals: Shop Drawings:

1. Complete dimensional fabrication drawings of surge tank, accessories (including those required for cathodic protection), and piping.
2. Complete piping schematic drawings showing air and liquid piping, and flows directly associated with surge tank.
3. Fabrication drawings of surge control tank panel.
4. Complete electrical elementary diagrams and electrical interconnection diagrams for surge control tank. Diagrams in accordance with NEMA ICS 1.
5. Complete interior and exterior tank painting systems.
6. Seismic anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.
7. Galvanic anode cathodic protection system in accordance with Section 26 42 02, Galvanic Anode Cathodic Protection System, for approval by Contractor.

B. Informational Submittals:

1. Seismic anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Statements of Qualification: Tank welders.
3. Tank manufacturer’s written instructions.

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4. Manufacturer's Certificate of Compliance, in accordance with Section 01 43 33, Manufacturers' Field Services, that tank is certified and stamped in accordance with ASME Section VIII, Division 1.
5. Test Reports:
    a. Date and time of testing.
    b. Description of method of testing, including pumping combinations and pressure records.
    c. Description of observed leaks and method and date of repair.
    d. Description of catastrophic failures.
6. Manufacturer's Certificate of Proper Installation, in accordance with Section in accordance with Section 01 43 33, Manufacturers' Field Services.

1.03 QUALIFICATIONS

A. Tank welders shall be ASME certified.

PART 2 PRODUCTS

2.01 SURGE TANK

A. Physical Data:

1. Net Volume: Not less than 3,700 gallons.
2. Configuration: Horizontal cylindrical shape with elliptical heads.
3. Type: Bladder.
4. Diameter: Approximately 6 feet.
5. Sidewall Length: Approximately 16 feet.
6. Design Pressure: Rated for 230 psig.
7. Design Temperature: 70 degrees F.

B. Attachments:

1. Elliptical Manhole(s): One minimum, design and fabricate in accordance with ASME Boiler and Pressure Vessel Code, Section VIII, Article D10.
2. Nozzles:
    a. As shown and in accordance with ASME Code, Section VIII, Article D6.
    b. Sizes 2-1/2 Inches and Larger: 150# flanged, ASME B16.5.
    c. Sizes 2 Inches and Smaller: 150# screwed, ASME B16.11.
    d. Number and Type:
        1) One 20-inch inlet/outlet nozzle.
        2) One 1/2-inch add/vent air nozzle.
        3) One 1/2-inch pressure relief nozzle.

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4) One 1/2-inch nozzle sized as required for level sensing probes.
5) Two 1/2-inch level gauge nozzles.
6) One 24-inch manway nozzle.
7) One 16-inch manway nozzle.

3. Pressure Relief (Safety) Valve:
   a. In accordance with Boiler and Pressure Vessel Code, Section VIII, General Requirements, UG-125 and 126.
   b. Sized and provided by tank supplier.
4. Tank Cradle: Approximately 38-inches from each tank end.
5. Visual Level Gauges: One, length per manufactures design.

C. Bladder: Bladder material must comply with ANSI/NSF61 and AWWA D130 standards.

D. Equipment Tag Numbers: TNK36010802

E. Lifting Lugs: Provide suitably attached for equipment assemblies and components weighing over 100 pounds.

F. Equipment Identification Plates: Provide 16-gauge Type 316 stainless steel identification plate securely mounted on each separate equipment component and control panel in a readily visible location. Plate shall bear 3/8-inch high engraved block type black enamel filled equipment identification number and letters indicated in this Specification.

G. Anchor Bolts: Type 316 stainless steel, sized by equipment manufacturer, and as specified in Section 05 50 00, Metal Fabrications. Coat in accordance with Section 09 90 00, Painting and Coating.

H. Controls: In accordance with general control requirements and component qualities specified in Contract Documents.

2.02 FABRICATION

A. Fabricate tank in accordance with ASME Boiler and Pressure Vessel Code, Section VIII.

B. Fabricate of welded carbon steel.

C. Plate Thicknesses: Determine in accordance with allowable stresses listed in the Code for material, pressure, and temperature specified.

D. Heads: As specified in ASME Code, Section VIII, Division 1.

E. Shell and Head Thicknesses: Include minimum corrosion allowance of 0.125 inch.

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F. Stamp and certify tank in accordance with ASME Code Section VIII, Division 1.

G. Interior (Submerged) Surface Treatment: Clean and paint in accordance with Section 09 90 00, Painting and Coating.

H. Exterior Surface Treatment: Clean and paint in accordance with Section 09 90 00, Painting and Coating.

2.03 SOURCE QUALITY CONTROL

A. Hydrostatically test tank in shop at 1.5 times design pressure for at least for 24 hours.

B. Repair leaks found during testing prior to painting.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install tank in accordance with manufacturer's written instructions.

B. Level tank and grout support legs or saddles before anchoring.

C. Assemble Accessories: Make process, control, and electrical connections.

D. Make piping connections such that misalignment stresses are not induced in tank nozzles.

3.02 FIELD QUALITY CONTROL

A. Field Static Test:

1. Hydrostatically test installed surge control tank for 4 hours minimum at 1.5 times design pressure, before dynamic testing.
2. Repair leaks detected during testing.

B. Functional Test:

1. Dynamic Test: Perform in response to flow startup and stoppage.
2. Testing with Multiple Pumps: Increase number of pumps, one at a time.
3. Record pressures for dynamic operation of each pump combination in startup and shutdown of flow.
4. Inspect and test components for alignment, operation, and connection, and performance.

END OF SECTION

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SECTION 33 12 19
WATER UTILITY DISTRIBUTION FIRE HYDRANTS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Water Works Association (AWWA):
   a. C502, Dry-Barrel Fire Hydrants.
   b. C503, Wet Barrel Fire Hydrants.
   c. C600, Installation of Ductile-Iron Mains and Their Appurtenances.
2. ASTM International (ASTM): C94, Standard Specification for Ready-Mixed Concrete.
3. FM Global Approved.
4. NSF International (NSF):
   a. NSF/ANSI 61, Drinking Water System Components - Health Effects.
   b. NSF/ANSI 372, Drinking Water System Components - Lead Content.
5. Underwriters Laboratories, Inc. (UL): 246, Standard for Hydrants for Fire-Protection Service.

1.02 SUBMITTALS

A. Action Submittals: Catalog cuts of system components.

1. Include calculations for thrust blocks for high-pressure installations (if required).

B. Informational Submittal:

1. Certificate of Compliance: Upon completion of the system installation, verify all fire department hose connections, and check all fire safety devices to ensure their readiness for emergency connection and operation.

PART 2 PRODUCTS

2.01 GENERAL

A. Components and Materials in Contact with Water for Human Consumption: Comply with the requirements of the Safe Drinking Water Act and other applicable federal, state, and local requirements. Provide certification by

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manufacturer or an accredited certification organization recognized by the Authority Having Jurisdiction that components and materials comply with the maximum lead content standard in accordance with NSF/ANSI 61 and NSF/ANSI 372.

1. Use or reuse of components and materials without a traceable certification is prohibited.

2.02 LOW PRESSURE HYDRANTS

A. Hydrant:

1. Break flange type.
2. Nominal 4-1/2 or 5-1/4-inch main valve opening with 6-inch bottom connections.
3. Conform to AWWA C502or AWWA C503.
4. Two 2-1/2-inch hose nozzles.
5. One 4-1/2-inch pumper nozzle.
6. Dry barrel type.
7. Operating Nuts: 1-1/2-inch National Standard pentagon nut.
8. Mechanical joint inlet connection.
9. Red aboveground line.
10. Manufacturers and Product:
    a. Mueller Co.
    b. American; Kennedy Valve.

B. Main Valve:

1. Depth of Bury: 3-1/2 feet.
2. Equip with O-ring seals.
3. Valve opens on counterclockwise rotation.

2.03 PRECAST CONCRETE PIER BLOCK

A. Nominal dimensions of 8-inch thickness by 16-inch square base.

B. Compressive Strength: 3,000 psi at 28 days.

2.04 GRAVEL FOR DRAINAGE

A. 3/4-inch drainage gravel. Free of organic matter, sand, loam, clay, and other small particles that will restrict water flow through gravel.

2.05 FOUNDATION STABILIZATION MATERIAL

A. Furnish when existing trench material or imported pipe base material will not support soft or flooded spots in excavated trench.

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B. Maximum 3-inch hard rock free from excessive clay material, but enough fines to bind larger fragments.

2.06 THRUST TIES

A. 3/4-inch-diameter steel rods.

B. Duc-Lugs Manufacturer: Romac.

PART 3 EXECUTION

3.01 GENERAL

A. Install hydrants in accordance with Section 3.7 and Section 3.8 of AWWA C600, unless specified otherwise.

3.02 EXCAVATION

A. Excavate to subgrade. Fill over excavated areas with foundation stabilization material. Tamp to provide firm foundation.

3.03 BASE BLOCK

A. Place on firm, level subgrade to ensure uniform support.

3.04 INSTALLATION OF HYDRANTS

A. Locate hydrants to provide accessibility and to minimize potential damage from vehicles.

1. Relocate improperly set hydrants.
2. Hydrant Located behind Curbs: Set barrel so pumper nozzle or hose nozzle caps are a minimum of 18 inches from gutter face of curb.
3. Hydrant Located in Space between Curb and Sidewalk: Not less than 8 inches, clear from sidewalks.
4. Hydrant Located between Sidewalk and Property Line: Minimum clearance 8 inches from sidewalk.
5. Set hydrants so safety flange is a minimum of 2 inches above finished ground or sidewalk level.

B. Place hydrant on base block carefully to prevent the base block from breaking.

C. Joints shall conform to Section 3.4 of AWWA C600 when cast or ductile iron pipe is used.

D. Maintain hydrant in a plumb position during subsequent Work.

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3.05 GRAVEL FOR DRAINAGE

A. Place gravel around base block and hydrant bottom in accordance with Section 3.7 of AWWA C600.

3.06 THRUST TIES

A. Install thrust ties in lieu of concrete thrust blocking when ground surface behind hydrant is less than 2 feet above top of hydrant base.

1. Install two tie rods between main valve and hydrant, water main tee and main valve**.**
2. Install mechanical joint glands with lugs in joints between hydrant and main line tee.

END OF SECTION

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SECTION 33 13 00
DISINFECTION OF WATER UTILITY DISTRIBUTION FACILITIES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Water Works Association (AWWA):
   a. B300, Hypochlorites.
   b. B301, Liquid Chlorine.
   c. B302, Ammonium Sulfate.
   d. B303, Sodium Chlorite.
   e. C651, Disinfecting Water Mains.
   f. C652, Disinfection of Water Storage Facilities.
   g. C653, Disinfection of Water Treatment Plants.
2. NSF International (NSF):
   a. NSF/ANSI 61, Drinking Water System Components - Health Effects.
   b. NSF/ANSI 372, Drinking Water System Components - Lead Content.
3. Standard Methods for the Examination of Water and Wastewater, as published by American Public Health Association, American Water Works Association, and the Water Environment Federation.

1.02 SUBMITTALS

A. Informational Submittals:

1. Plan describing and illustrating conformance to appropriate AWWA standards and this Specification. Plan shall include:
   a. Procedure and plan for cleaning system.
   b. Preliminary flushing sequence and procedures.
   c. Procedures and plans for disinfection and testing.
   d. Proposed locations within system where Samples will be taken.
   e. Type of disinfecting solution and method of preparation.
   f. Method of disposal for highly chlorinated disinfecting water.
2. Independent Testing Agency: Certification that testing agency is qualified to perform bacteriological testing in accordance with AWWA standards, agency requirements, and this Specification.
3. Certified Bacteriological Test Results:
   a. Facility tested is free from coliform bacteria contamination.
   b. Forward results directly to Contractor.

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1.03 QUALITY ASSURANCE

A. Independent Testing Agency: Certified in the State of New Mexico, with 10 years' experience in field of water sampling and testing. Agency shall use calibrated testing instruments and equipment, and documented standard procedures for performing specified testing.

PART 2 PRODUCTS

2.01 GENERAL

A. Components and Materials in Contact with Water for Human Consumption: Comply with the requirements of the Safe Drinking Water Act and other applicable federal, state, and local requirements. Provide certification by manufacturer or an accredited certification organization recognized by the Authority Having Jurisdiction that components and materials comply with the maximum lead content standard in accordance with NSF/ANSI 61 and NSF/ANSI 372.

1. Use or reuse of components and materials without a traceable certification is prohibited.

2.02 WATER FOR DISINFECTION AND TESTING

A. Clean and uncontaminated.

B. Make arrangements for water supply and convey water in disinfected pipelines or containers.

2.03 DISINFECTANT

A. The following disinfectant product(s) shall not be used: Chloramines.

B. Chlorine type (gas, delivered sodium hypochlorite, or on-site generated sodium hypochlorite) as determined by Contractor shall be used for disinfectant procedures.

PART 3 EXECUTION

3.01 GENERAL

A. Conform to AWWA C651 for pipes and pipelines, C652 for tanks and reservoirs, and C653 for water treatment plants and filters, except as modified in these Specifications.

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B. All surfaces in contact with raw or partially treated downstream of clarification facilities through Tank #3 shall be cleaned, flushed, and disinfected in accordance with this Specification.

C. Contractor's Equipment: Furnish chemicals and equipment, such as pumps and hoses, to accomplish disinfection.

D. Disinfect the following items installed or modified under this Project, intended to hold, transport, or otherwise contact potable water:

1. Tanks.
2. Water treatment plant.
3. Pipelines: Disinfect new pipelines that connect to existing tanks and pipelines up to point of connection.
4. Disinfect surfaces of materials that will contact finished water, both during and following construction, using one of the methods described in AWWA C651, AWWA C652 and AWWA C653. Disinfect prior to contact with finished water. Take care to avoid recontamination following disinfection.

E. Prior to application of disinfectants, clean system from outlet of clarification facilities through Tank #3 of loose and suspended material.

F. Allow freshwater and disinfectant solution to flow into pipe or vessel at a measured rate so chlorine-water solution is at specified strength. Do not place concentrated liquid commercial disinfectant in pipeline or other facilities to be disinfected before it is filled with water.

G. Disinfected structures shall be protected from contamination after being acceptably disinfected.

3.02 SEQUENCING AND SCHEDULING

A. Disinfect the system from upstream to downstream First disinfect the filters, then disinfect the GAC contactors, then disinfect the clearwell and associated pumping systems, then the finished water pipeline, and finally Tank #3.The filters and GAC contactor shall be disinfected prior to media installation.

3.03 PIPING AND PIPELINES

A. Cleaning:

1. Before disinfecting, clean foreign matter from pipe in accordance with AWWA C651.
2. If continuous feed method or slug method of disinfection, as described in AWWA C651, are used flush pipelines with potable water until clear of suspended solids and color. Provide hoses, temporary pipes, ditches,

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and other conduits as needed to dispose of flushing water without damage to adjacent properties.

3. Flush service connections and hydrants. Flush distribution lines prior to flushing hydrants and service connections. Operate valves during flushing process at least twice during each flush.
4. Flush pipe through flushing branches and remove branches after flushing is completed.

B. Disinfecting Procedure: In accordance with AWWA C651, unless herein modified.

3.04 TANKS AND RESERVOIRS

A. Cleaning:

1. Clean interior surfaces using water under pressure before sterilizing.
2. Isolate tank and reservoir from system to prevent contaminating materials from entering distribution system.
3. Cleaning shall:
   a. Remove deposits of foreign nature.
   b. Remove biological growths.
   c. Clean slopes, walls, top, and bottom.
   d. Avoid damage to structure.
   e. Avoid pollution or oil deposits by workers and equipment.
4. Dispose of water used in cleaning in accordance with applicable regulations before adding disinfecting solution to tank and reservoir.

B. Disinfecting Procedure: In accordance with AWWA C652, unless herein modified. Parts of structures, such as ceilings or overflows that cannot be immersed, shall be spray or brush disinfected.

3.05 WATER TREATMENT PLANT

A. Prior to disinfection, remove foreign material from water treatment plant structures. Clean using fire hoses and tools suitable for adequate scrubbing and cleaning. Pump or drain scrub water from structures.

B. Disinfection Procedure: In accordance with AWWA C651, C652, and/or C653, unless herein modified.

3.06 DISPOSAL OF CHLORINATED WATER

A. Do not allow flow into a waterway without neutralizing disinfectant residual.

B. See appendix of AWWA C651, C652, and C653 for acceptable neutralization methods.

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3.07 TESTING

A. Collection of Samples:

1. Coordinate activities to allow Samples to be taken in accordance with this Specification.
2. Provide valves at sampling points.
3. Provide access to sampling points.

B. Test Equipment:

1. Clean containers and equipment used in sampling and make sure they are free of contamination.
2. Obtain sampling bottles with instructions for handling from an independent testing laboratory.

C. Chlorine Concentration Sampling and Analysis:

1. Collect and analyze Samples in accordance with AWWA Standards.
2. Sampling Locations: Consistent with bacteriological sampling locations.
3. Analysis to be performed by Contractor or an independent test laboratory.

D. After tanks, reservoirs, water treatment plant, pumps, and pipelines have been cleaned, disinfected, and refilled with potable water, an independent laboratory will take water Samples and have them analyzed for conformance to bacterial limitations for public drinking water supplies.

1. Collect Samples in accordance with applicable AWWA Standard.
2. Analyze Samples for coliform concentrations in accordance with latest edition of Standard Methods for the Examination of Water and Wastewater.
3. Obtain and analyze samples per AWWA C651, C652, and C653 as applicable.
4. Sampling points shall be representative and accepted by Contractor.

E. If minimum Samples required above are bacterially positive, an additional set of tests shall be performed and confirm the results of the initial tests. If repeat tests indicate positive results, disinfecting procedures and bacteriological testing shall be repeated until bacterial limits are met for two consecutive sets of samples taken 24 hours apart. The Contractor must provide final approval of results prior to placing structures or pipelines into service.

END OF SECTION

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SECTION 33 16 13.10
WELDED STAINLESS STEEL TANKS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Petroleum Institute (API): STD 650, Welded Steel Tanks for Oil Storage.
2. American Society of Mechanical Engineers (ASME):
   a. B16.5, Pipe Flanges and Flanged Fittings.
   b. B16.11, Forged Fittings, Socket-Welding and Threaded.
   c. B31.3, Process Piping.
   d. BPVC SEC VIII, Division 1, Rules for Construction of Pressure Vessels.
   e. BPVC SEC IX, Qualification Standard for Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators.
3. American Society of Civil Engineers (ASCE): ASCE 7, Minimum Design Loads for Buildings and Other Structures.
4. American Society of Nondestructive Testing (ASNT): SNT-TC-1A, Personnel Qualification and Certification in Non-Destructive Testing.
5. American Society of Safety Engineers (ASSE): Z359.1, Safety Requirements for Personal Fall Arrest Systems, Subsystems and Components.
6. ASTM International (ASTM):
   a. A181/A181M, Standard Specification for Carbon Steel Forgings, for General-Purpose Piping.
   b. A193/A193M, Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High Temperature or High Pressure Service and Other Special Purpose Applications.
   c. A194/A194M, Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High-Pressure of High-Temperature Service, or Both.
   d. A234/A234M, Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service.
   e. A516/A516M, Standard Specification for Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service.
   f. F1554, Standard Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength.

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7. American Welding Society (AWS):
    a. A2.4, Standard Symbols for Welding, Brazing, and Nondestructive Examination.
    b. A3.0, Standard Welding Terms and Definitions; Including Terms for Adhesive Bonding, Brazing, Soldering, Thermal Cutting, and Thermal Spraying.
    c. D1.1/D1.1M, Structural Welding Code - Steel.
    d. D1.6/D1.6M, Structural Welding Code – Stainless Steel.
    e. D18.2, Guide to Weld Discoloration Levels.
    f. QC 1, Standard for AWS Certification of Welding Inspectors.
8. International Building Code (IBC).
9. National Association of Corrosion Engineers (NACE):
    a. NACE Standard RP0391, Materials for the Handling and Storage of Commercial Concentrated (90 to 100%) Sulfuric Acid at Ambient Temperatures.
    b. NACE SP0294, Design, Fabrication, and Inspection of Storage Tank Systems for Concentrated Fresh and Process Sulfuric Acid and Oleum at Ambient Temperatures.
10. National Electrical Manufacturers Association (NEMA): 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
11. Occupational Safety and Health Act (OSHA): 29 CFR 1910, Code of Federal Regulations.

1.02 WORK OF THIS SECTION

A. The Work of this section includes providing one welded stainless steel sulfuric acid storage tank and all appurtenant work.

B. General Requirements: See Division 1, General Requirements, which contains information and requirements that apply to the Work specified herein and are mandatory for this Project.

1.03 SUBMITTALS

A. All submittal information shall be provided in English.

B. General: Administrative, shop drawings, samples, quality control, and contract closeout submittals shall conform to the requirements of the Statement of Work.

C. Shop Drawings and Samples: Provide shop drawings in conformance with the requirements of the Statement of Work.

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D. In addition to the requirements of the Statement of Work, submit the following additional detailed shop drawing information:

1. Calculations of steel tank sealed by a professional engineer, registered in the State of Tennessee.
2. Shop drawings in accordance with Section 05 05 23, Welding.
3. Complete specifications, dimensional drawings, and descriptive literature on the tanks and their accessories to be furnished, including:
   a. Materials of construction.
   b. Shell height and plate thickness.
   c. Type and thickness of roof.
   d. Type and thickness of the bottom plates.
   e. Location of all circumferential and longitudinal welded joints.
   f. Dimension, location, and details of all nozzles, and accessories such as manways. Identify all tank nozzles with the identification mark shown on the Tank Data Sheets.
   g. Tank data indicating equipment number, pressure rating, and details of nozzle designs.
4. Manufacturer's literature and catalog data of components.
5. Tank designer's detailed requirements for tank anchorage.

E. Quality Control Submittals: Conform to the requirements of the Statement of Work and Section 05 05 23, Welding.

F. Operation and Maintenance Manual and Maintenance Summary: Provide an Operation and Maintenance Manual and Maintenance Summary in conformance with the requirements of Section 01 78 23, Operation and Maintenance Data.

1.04 GUARANTEE

A. The Supplier shall guarantee the materials and workmanship of the tank and its appurtenances for a period of 24 months from date of installation.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Where a manufacturer's standard equipment name and/or model number is listed, the equipment system shall be provided as modified to conform to the performance, functions, features, and materials of construction as specified herein.

B. Materials, equipment, components and accessories specified in this section shall be products of:

1. Fisher Tank.

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2. Landmark Structures.
3. Associated Tank Constructors, Inc.
4. Approved equal.

2.02 DESIGN CONDITIONS

A. Liquid: 93 percent sulfuric acid.

B. Specific Gravity: 1.84 at 60 degrees F.

C. Design Pressure: 0.50 psig positive pressure and 0.15 psig vacuum.

D. Design Temperature: Refer to Section 01 61 00, Common Product Requirements.

E. Location: Outdoors under roof structure.

F. Site Elevation: 6625.00 feet

G. Design for wind and seismic loads in accordance with the latest edition of the International Building Code (IBC) by the International Code Council. Refer to Section 01 61 00, Common Product Requirements. Also see Section 01 88 15, Anchorage and Bracing.

2.03 GENERAL REQUIREMENTS

A. See Section 01 61 00, Common Product Requirements, for specific requirements related to the equipment specified herein.

B. Materials:

1. Tank Plates: ASTM A240, Type 316L stainless steel. Shaped and bent in the shop to exact radius required.
2. Bolts, Anchor Bolts, and Hex Nuts: Type 316 stainless steel.
3. Minimum Thickness of Plate for Floor, Shell, and Roof: 3/16 inch.
4. Metal Design and Fabrication: In accordance with applicable AISC codes of standard practice. Plates and shapes shall be sheared, sawn, or machined true to dimensions shown. Joining of parts shall be by welding. Grind exposed and rough edges to a smooth, uniform radius.

C. Design:

1. Tanks: Designed, fabricated, and inspected in accordance with current API 650 standard requirements, except as modified by NACE SP0294, and these Specifications..
2. Constructed with continuous complete joint penetration groove welds, inside and out. The vessel shall be completely shop welded with no

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field welding permitted. The tank shall be fabricated from a minimum number of pieces. All longitudinal shell seams shall be staggered. Shell seams shall be located to clear all nozzle openings.

3. Dimensions, capacities, nozzle locations, and design information for the tank to be provided are described on the attached Tank Data Sheets.
4. The Contractor shall be responsible for the design of the welded steel tanks, based on these Specifications, the associated Tank Data Sheets, and Section 01 61 00, Common Product Requirements.
5. Welded joints shall be inspected using radiographic testing wherever possible. Joints which cannot be radiographically tested shall be 100 percent ultrasonically examined.
6. Welds shall be cleaned and passivated in accordance with ASTM A380 after all other work in the area of installation is complete. A second cleaning and passivating treatment may be required by the Buyer's Technical Representative (BTR) if contamination occurs during installation.

D. Nozzles:

1. Unless specified otherwise, shell side nozzle centerlines shall intersect and be perpendicular to the tank axial centerline. Centerlines of nozzles in ends of tanks shall be parallel to the tank axial centerline.
2. Nozzle flanges shall be ASME B16.5 Class 150, raised-face, weld neck style unless noted otherwise. Where specified, ring flanges with a full fillet weld at the junction of the flange face and the edge of the nipple may be used. Grind smooth to a 1/8-inch minimum radius.
3. Unless specified otherwise, flanged nozzle projection shall be 6 inches (nozzle face to nearest outside tank surface). Flange bolt holes shall symmetrically straddle the tank centerlines.
4. Gasket surfaces shall be flat and parallel within 1/16 inch from the tank centerline over the flange width.

2.04 ACCESSORIES

A. Side Manways: As shown on the attached Tank Data Sheets. Minimum clear opening of 30 inches unless otherwise noted. Furnish flanged and bolted type cover with confined gasket. Hinge cover to tank shell. Grind welds and sheared edges smooth. Type 316 stainless steel bolts and nuts.

B. Conservation Vent (XXXXXXXX):

1. Size: 8 inches.
2. Pressure Setting: 3.5 ounces per square inch.
3. Vacuum Setting: 2.0 ounces per square inch.
4. Flanges: ANSI Class 125 bolting specification.

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5. Material: PVC base and cover with FEP film covered Type 316 pallets. All elastomers shall be Viton.
6. Manufacturer and Product: Protectoseal; Model PVC8546B.

C. Gaskets: Two sets (one spare) of 1/8-inch thick full-face gaskets for all flanged nozzles and manways. Gasket material shall be Viton.

D. Equipment Identification Plates: 16-gauge Type 316 stainless steel identification plates shall be securely mounted on each tank in a readily visible location with stainless steel screws or drive pins. Nameplates shall contain the manufacturer's name, model, serial number, size, and characteristics. Tank nameplates shall include the information required by API 650, including, but not limited to:

1. Equipment tag number.
2. Name of tank manufacturer.
3. Tank capacity.
4. Material specification.
5. Date of manufacturer.

E. Lifting Lugs: Provide for all tanks. Quantity and location as recommended by tank manufacturer.

2.05 TESTING

A. After fabrication, hydrostatic pressure test the tank with water containing 1 ppm of free chlorine (to prevent microbial induced corrosion).

B. Fill tank with water and pressurize to 0.2 psig. Pressure shall be held for 1 hour without loss of pressure or sign of leaks.

2.06 SOURCE QUALITY CONTROL

A. Certified Welding Inspector (CWI) shall be present whenever welding is performed. CWI shall perform inspection at suitable intervals prior to assembly, during assembly, during welding, and after welding. CWI duties include:

1. Verifying conformance of specified job material and proper storage.
2. Monitoring conformance with approved WPS.
3. Monitoring conformance of WPQ.
4. Inspecting weld joint fit-up and in-process inspection.
5. Providing 100 percent visual inspection of welds.
6. Supervising nondestructive testing personnel and evaluating test results.
7. Maintaining records and preparing report confirming results of inspection and testing comply with the Work.

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B. Welding inspection is part of the Contractor's Quality Control and is a separate function from Fabrication. The CWI cannot also be a production welder on the project.

C. Weld Non-Destructive Testing (NDT):

1. 100 percent Visual Inspection (VT) by CWI of all welds for acceptance in accordance with AWS D1.6, Section 6.28 for Statically Loaded Nontubular Connections, unless more stringent NDT is required in this specification section. Heat tint shall not exceed Level 3 per AWS D18.2.
2. Shell:
    a. Butt Joint Groove Welds: Random 10 percent Radiographic Inspection (RT) examine, unless more frequent RT examination is required by API 650 for tank service class.
        1) Comply with AWS D1.6, Section 6, Part B and AWS D1.6, Section 6.28.
    b. Openings:
        1) Groove Welds: 100 percent Ultrasonic Inspection (UT) per AWS D1.6, Part C and AWS D1.6, Section 6.28.
        2) Fillet Welds: 100 percent Liquid Penetrant Inspection (PT) per AWS D1.6, Sections 6.7.6 and 6.28 for Statically Loaded Nontubular Connections.
3. Floor Opening Welds: 100 percent examine using NDT methods specified for shell opening welds.
4. Anchor Bolt Attachment Welds:
    a. 100 percent NDT of all welds that support first three consecutive anchor bolts at tank base as follows:
        1) Fillet Welds: PT per AWS D1.6, Sections 6.7.6 and 6.28 for Statically Loaded Nontubular Connections.
        2) Groove Welds: UT per AWS D1.6, Part C and AWS D1.6, Section 6.28.
    b. If rejection rate exceeds 5 percent, 100 percent examine next three anchor bolt supports using same testing procedures and acceptance criteria.
    c. If rejection rate is less than 5 percent, testing rate may be reduced to 20 percent of welded connections.
    d. Engineer will determine welds to be tested.
5. Accessories and Attachments: PT at 10 percent rate per AWS D1.6 for Statically Loaded Nontubular Connections.

D. Visual Inspection: Perform visual inspection. Acceptance standards in accordance with ANSI/AWS D1.6, Paragraph 6.2 and additional nondestructive testing requirements as specified herein and Section 05 05 23, Welding.

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PART 3 EXECUTION

3.01 INSTALLATION

A. In accordance with manufacturer's written instructions.

B. Anchor Bolts: Accurately place using templates furnished by manufacturer and as specified in Section 05 50 00, Metal Fabrications.

3.02 MANUFACTURER'S FIELD SERVICES

A. Provide manufacturer's representative at site for 1 person-day in accordance with Section 01 43 33, Manufacturers' Field Services, and the UCOR-4931, Outfall 200 Mercury Treatment Facility Startup Test Plan, for installation assistance, inspection, testing, and certification of proper installation.

3.03 SUPPLEMENTS

A. The supplements listed below, following "End of Section," are a part of this Specification.

1. Tank Data Sheet XXXXXXXX.

END OF SECTION

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SECTION 33 41 01
STORM DRAIN, SANITARY SEWER, AND DRAINAGE PIPING

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section and any supplemental Data Sheets:

1. American Association of State Highway and Transportation Officials (AASHTO):
   a. M36M, Standard Specification for Corrugated Steel Pipe, Metallic-Coated, for Sewers and Drains.
   b. M190M, Standard Specification for Bituminous Coated Corrugated Metal Culvert Pipe and Pipe Arches.
   c. M196M, Standard Specification for Corrugated Aluminum Pipe for Sewers and Drains.
2. American Water Works Association (AWWA):
   a. C104/A21.4, Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water.
   b. C105/A21.5, Polyethylene Encasement for Ductile-Iron Pipe Systems.
   c. C110/A21.10, Ductile-Iron and Gray-Iron Fittings, 3 in. Through 48 in. (75 mm Through 1200 mm) for Water and Other Liquids.
   d. C111/A21.11, Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
   e. C151/A21.51, Ductile-Iron Pipe, Centrifugally Cast, for Water.
3. ASTM International (ASTM):
   a. A746, Standard Specification for Ductile Iron Gravity Sewer Pipe.
   b. C14, Standard Specification for Concrete Sewer, Storm Drain, and Culvert Pipe.
   c. C76, Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe.
   d. C150, Standard Specification for Portland Cement.
   e. C311, Standard Test Methods for Sampling and Testing Fly Ash or Natural Pozzolans for Use as a Mineral Admixture in Portland-Cement Concrete.
   f. C361, Standard Specification for Reinforced Concrete Low-Head Pressure Pipe.
   g. C425, Standard Specification for Compression Joints for Vitrified Clay Pipe and Fittings.
   h. C443, Standard Specification for Joints for Circular Concrete Sewer and Culvert Pipe, Using Rubber Gaskets.

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i. C497, Standard Test Methods for Concrete Pipe, Manhole Sections, or Tile.
j. C507, Standard Specification for Reinforced Concrete Elliptical Culvert, Storm Drain, and Sewer Pipe.
k. C595, Standard Specification for Blended Hydraulic Cements.
l. C618, Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete.
m. C655, Standard Specification for Reinforced Concrete D-Load Culvert, Storm Drain, and Sewer Pipe.
n. C700, Standard Specification for Vitrified Clay Pipe, Extra Strength, Standard Strength, and Perforated.
o. C1012, Standard Test Method for Length Change of Hydraulic-Cement Mortars Exposed to a Sulfate Solution.
p. D1248, Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable.
q. D1784, Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.
r. D2412, Standard Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading.
s. D3034, Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings.
t. D3212, Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals.
u. F477, Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.
v. F679, Standard Specification for Poly(Vinyl Chloride) (PVC) Large-Diameter Plastic Gravity Sewer Pipe and Fittings.
w. F794, Standard Specification for Poly(Vinyl Chloride) (PVC) Profile Gravity Sewer Pipe and Fittings Based on Controlled Inside Diameter.
x. F894, Standard Specification for Polyethylene (PE) Large Diameter Profile Wall Sewer and Drain Pipe.

1.02 SUBMITTALS

A. Informational Submittals: Manufacturer’s Certification of Compliance.

PART 2 PRODUCTS

2.01 PIPE AND FITTINGS

A. As specified in the Data Sheets following “End of Section.”

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2.02 SERVICE AND DRAIN CONNECTIONS

A. Pipe and fittings for individual service connection shall be of one type of material throughout.

PART 3 EXECUTION

3.01 INSTALLATION OF PIPE, FITTINGS, AND APPURTENANCES

A. General:

1. Pipe laying shall proceed upgrade with spigot ends pointing in direction of flow.
2. Excavate bell holes at each joint to permit correct assembly and inspection of entire joint.
3. Pipe invert may deviate from line or grade up to 1/2 inch for line and 1/4 inch for grade, provided that finished pipe line will present a uniform bore, and such variation does not result in a level or reverse sloping invert, or less than minimum slope shown.
4. Pipe bedding shall form continuous and uniform bearing and support for pipe barrel between joints. Pipe shall not rest directly on bell or pipe joint.
5. Prevent entry of foreign material into gasketed joints.
6. Plug or close off pipes that are stubbed off for manhole, concrete structure, or for connection by others, with temporary watertight plugs.

B. Concrete Closure Collars: Only use concrete closure collars where shown or authorized by Contractor.

C. Service Connections:

1. Minimum Slope: 1/4 inch per foot.
2. Markers:
   a. Paint the top portion of the marker immediately after its installation with first-quality white, quick-drying enamel. After the paint has dried, use black, quick-drying enamel and neatly indicate the distance from the natural ground surface to the top of the service connection pipe in feet and inches.
   b. If marker is broken or knocked out of vertical alignment during backfilling operation, reopen trench and place marker in accordance with Sewer Service Connection Details shown on Drawings.

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D. Square-End Underdrains: Cover top and sides of the joints with a strip of asphalt-saturated 30-pound roofing felt.

E. Perforated Underdrain: Lay with open joints and with perforations down.

3.02 REPAIR AND RETESTING

A. Sections of pipe not meeting the pressure test requirements shall be replaced.

B. Following repairs, sections shall be retested as specified.

3.03 SEWER CLEANING

A. Prior to final acceptance and final manhole-to-manhole inspection of the sewer system by Contractor, flush and clean all parts of the system. Remove all accumulated construction debris, rocks, gravel, sand, silt, and other foreign material from the sewer system at or near the closest downstream manhole. If necessary, use mechanical rodding or bucketing equipment.

B. Upon Contractor's final manhole-to-manhole inspection of the sewer system, if any foreign matter is still present in the system, reflush and clean the sections and portions of the lines as required.

3.04 SUPPLEMENTS

A. Data Sheets.

Number	Title
-.03	Polyvinyl Chloride (PVC)
-.05	Reinforced Concrete

END OF SECTION

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SECTION 33 41 01.03 POLYVINYL CHLORIDE (PVC)	
Item	**Description**
General	Materials in contact with potable water shall conform to NSF 61/372 acceptance.
Pipe: 15-inch diameter and under	ASTM D3034: Standard dimension ratio less than 35, except that the cell classification shall be 12454-B or 12454-C as defined in ASTM D1784.
Pipe: 18- through 24-inch diameter	ASTM F679: Standard dimension ratio less than 35, except that the cell classification shall be 12454-C as defined in ASTM D1784.
Joints	ASTM D3212 rubber gasketed.
Gaskets	ASTM F477. Lubricants: As approved by manufacturer.
Fittings	PVC, gasketed. Provide plug when service piping is not required.
Plugs	Removable. Removal shall provide a socket suitable for making a flexible jointed lateral connection or extension.
Source Quality Control Testing	In accordance with specified ASTM.

END OF SECTION

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SECTION 33 41 01.05 REINFORCED CONCRETE	
Item	**Description**
Pipe	ASTM C76, Wall B, class as shown. Mark each joint with pipe class. Rotating packer or platform not allowed.
Cement	ASTM C150, Type II, or ASTM C150, Type I, with fly ash; maximum 12 percent Tricalcium Aluminate, or ASTM C595 Rev A, Type IP, with fly ash; Cement: ASTM C150. Minimum 564 pounds per cubic yard without fly ash. Minimum 479 pounds per cubic yard with fly ash.
Ratio: Water to Cementitious Materials	Not over 0.49.
Fly Ash	ASTM C618, Class C or Class F, Tables 1 and 2 modified as follows: Loss on Ignition: Maximum 3 percent Water Requirement: Maximum 100 percent of control Ratio Percent CaO/Fe_2O_3: Maximum 1.5 or test cement fly ash mix in accordance with ASTM C1012. Mix: Equal to or better than ASTM C150, Type II cement. 85 pounds per cubic yard minimum, 160 pounds per cubic yard maximum. Test: ASTM C311 and ASTM C618.
Joints	ASTM C443 Rev A. Captive gasket in groove.
Rubber Gaskets	ASTM C443.
Circumferential Reinforcement	Not closer than 1 inch to inside surface of pipe. Area of outer circular reinforcing cage not less than 75 percent of inner cage.
Elliptical Reinforcement	Not allowed.

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SECTION 33 41 01.05 REINFORCED CONCRETE	
Item	**Description**
Source Quality Control Testing	Load Bearing 0.01-inch Crack, Compressive Strength and Absorption: ASTM C76 Load Bearing Ultimate: ASTM C76. Permeability: ASTM C497. Voids: Longitudinally sawcut one pipe from each 100 lengths of pipe manufactured in half with saw that will not damage the concrete or reinforcing steel. Inspect for voids adjacent to circumferential bars. Voids will be considered continuous if a 1/16-inch diameter pin can be inserted 1/4 inch deep. If voids exist adjacent to more than 10 percent of the circumferential bars, two additional pipes shall be tested. If either of the two pipes fail, the entire 100 lengths will be rejected.

END OF SECTION

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SECTION 33 47 13.01
POND AND RESERVOIR LINERS—HDPE

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
   a. A193/A193M, Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High Temperature or High Pressure Service, and other Special Purpose Applications.
   b. A194/A194M, Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure and High Temperature Service, or both.
   c. A276, Standard Specification for Stainless and Steel Bars and Shapes.
   d. B211, Standard Specification for Aluminum and Aluminum-Alloy Bar, Rod, and Wire.
   e. C881/C881M, Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete.
   f. D570, Standard Test Method for Water Absorption of Plastics.
   g. D638, Standard Test Method for Tensile Properties of Plastics.
   h. D696, Standard Test Method for Coefficient of Linear Thermal Expansion of Plastics Between Minus 30 Degrees C and 30 Degrees C with Vitreous Silica Dilatormeter.
   i. D746, Standard Test Method for Brittleness Temperature of Plastics and Elastomers by Impact.
   j. D751, Standard Test Methods for Coated Fabrics.
   k. D792, Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement.
   l. D882, Standard Test Method for Tensile Properties of Thin Plastic Sheeting.
   m. D1004, Standard Test Method for Tear Resistance (Graves Tear) of Plastic Film and Sheeting.
   n. D1505, Standard Test Method for Density of Plastics by the Density-Gradient Technique.
   o. D1693, Standard Test Method for Environmental Stress-Cracking of Ethylene Plastics.
   p. D2240, Standard Test Method for Rubber Property-Durometer Harness.
   q. D4833, Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products.

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r. D5199, Standard Test Method for Measuring Nominal Thickness of Geosynthetics.
s. D5321, Standard Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method.
t. D5641, Standard Practice for Geomembrane Seam Evaluation by Vacuum Chamber.
u. D5994, Standard Test Method for Measuring Core Thickness of Textured Geomembrane.
v. D6392, Standard Test Method for Determining the Integrity of Nonreinforced Geomembrane Seams Produced Using Thermo-Fusion Methods.

1.02 DEFINITIONS

A. Boot: Watertight collar fabricated from geomembrane sheet for sealing geomembrane to pipes and other objects that penetrate geomembrane.

B. Film Tearing Bond: Failure in ductile mode of one bonded sheet, by testing, prior to complete separation of bonded area.

C. Geomembrane: Essentially impermeable geosynthetic composed of one or more layers of polyolefin materials fusion bonded into single-ply integral sheet.

D. Panel: Piece of geomembrane composed of two or more sheets seamed together.

E. Sheet: Seamless piece of geomembrane.

F. Watertight: Geomembrane installation free of flaws and defects that will allow passage of water and gases, liquids, and solids to be contained under anticipated service conditions.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
a. Manufacturer’s specifications, literature for each geomembrane furnished, and products used to complete installation.
b. Compensation allowance calculation and numerical values for temperature induced geomembrane expansion and contraction.
c. Polymer Resin: Product identification and Supplier.
d. Geomembrane sheet layout with proposed size, number, position, and sequence of sheet placement, and location of field seams.

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e. Proposed equipment for material placement.
f. Procedures for material installation.

B. Informational Submittals:

1. Qualifications:
   a. Manufacturer.
   b. Installer.
   c. **[A: Independent testing agency.]**
2. Quality Assurance Program: Written description of geomembrane manufacturer's and installer's formal programs for manufacturing, fabricating, handling, installing, seaming, testing, and repairing geomembrane.
3. Manufacturer's Certificate of Compliance, in accordance with Section **[B: 01 61 00, Common Product Requirements] [C:]**.
4. Production dates for geomembrane.
5. Testing:
   a. **[D: Factory QC test results for supplied geomembrane.]**
   b. **[E: Rough-surfaced geomembrane coefficient of interface friction test results.]**
   c. **[G: [G: Certified] Field seam test results.]**
   d. **[H: Laboratory Testing Equipment: Certified calibrations, manufacturer's product data, and test procedures.]**
6. Geomembrane Installer's Certification of Subsurface Acceptability: Form attached at end of this section.
7. Manufacturer's Certificate of Proper Installation, in accordance with Section **[I: 01 43 33, Manufacturers' Field Services] [J:]**.
8. Special guarantee.

1.04 QUALIFICATIONS

A. **[A: Independent Testing Agency:] [B: Certified in the State of] [C: ,] [D: and] 5 years' experience in field of geomembrane testing. Laboratory shall maintain calibrated instruments, equipment, and documented standard procedures for performing specified testing.]**

B. Manufacturer: Successfully manufactured a minimum of **[A: 10 million] [B:]** square feet of each type of geomembrane material specified.

C. Installer: Successfully installed a minimum of **[[A: 10 million] [B:] square feet] [[C: 10] [D:] projects]** of each type of geomembrane product specified in applications similar to the Project.

D. Minimum qualifications stated above will be deemed met if the firm or cumulative experience of key personnel (supervisors and trained installation/testing technicians) proposed for this Project has minimum experience specified. If key personnel provision is used to qualify the firm,

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submit letter stating key personnel meet the minimum experience requirements and those individuals are available for and will be committed to this Project.

1.05 COORDINATION MEETINGS

A. Meet at least once prior to commencing each of the following activities:

1. Submission of Submittals.
2. Manufacture of geomembrane sheets.
3. Fabrication of panels and boots.
4. Installation of geomembrane.

B. Attendees:

1. Contractor's designated quality control representative.
2. Engineer.
3. Representatives of geomembrane installer.
4. Others requested by Engineer.

C. Topics:

1. Specifications and Drawings.
2. Submittal requirements and procedures.
3. Schedule for beginning and completing geomembrane installation.
4. Training for installation personnel.
5. Installation crew size.
6. Establishing geomembrane marking system, to include sheet identification, defects, and satisfactory repairs, to be used throughout Work.

D. Seam Installation **[A: and Testing]** Demonstration: Performed by geomembrane installer, for each type of seam required.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Conform to requirements of Section 01 61 00, Common Product Requirements.

B. Geomembrane:

1. Individually package each sheet and protect from damage during shipment.
2. Mark each package with identification of material type, size, and weight.

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C. Epoxy Adhesive:

1. Storage Temperature:
   a. Control temperature above 60 degrees F and dispose of cartridges if shelf life has expired.
   b. If stored at temperatures below 60 degrees F, test adhesive prior to use to determine if adhesive meets specified requirements.

1.07 ENVIRONMENTAL REQUIREMENTS

A. Do not install geomembrane or perform seaming under the following conditions, unless it can be demonstrated to satisfaction of Engineer that performance requirements can be met under these conditions:

1. Air temperature is less than 35 degrees F or more than 90 degrees F.
2. Relative humidity is more than 90 percent.
3. Raining, snowing, frost is in ground, or wind is excessive.

B. Do not place granular materials on geomembrane when ambient temperature is less than 35 degrees F, unless it can be demonstrated to satisfaction of Engineer that materials can be placed without damage.

1.08 SEQUENCING AND SCHEDULING

A. **[A: Factory test results for supplied geomembrane materials shall be acceptable to Engineer prior to shipment of geomembrane.]**

B. Before placing geomembrane on soil surfaces, prepare subgrade as specified in Section 31 23 13, Subgrade Preparation.

C. Do not attach geomembrane to new concrete surfaces until after concrete has attained two-thirds of design compressive strength specified in Section 03 30 00, Cast-in-Place Concrete.

D. Do not place geomembrane over concrete surfaces until finish of concrete surfaces, as specified in Section 03 30 00, Cast-in-Place Concrete, is acceptable to Engineer.

1.09 SPECIAL GUARANTEE

A. Provide manufacturer’s extended guarantee or warranty, with Owner named as beneficiary, in writing, as special guarantee. Special guarantee shall provide for correction, or at option of Owner, removal and replacement of Work specified in this Specification section found defective during periods below, commencing on date of Substantial Completion. Duties and obligations for correction or removal and replacement of defective Work as specified in General Conditions.

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1. Guaranty geomembrane against manufacturing defects, deterioration due to ozone, ultraviolet, and other exposure to elements for period of **[A: 20 years on pro rata basis] [B:]**.
2. Guaranty geomembrane against defects in material and factory seams for period of **[C: 2 years] [D:]**.
3. Guaranty geomembrane against defects resulting from installation for period of **[E: 2 years] [F:]**.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. Geomembrane:

1. GSE Lining Technology, Inc., Houston, TX.
2. Poly-Flex, Inc., Grand Prairie, TX.
3. AGRU America, Georgetown, SC.

2.02 GEOMEMBRANE

A. Composition: **[A: High density polyethylene (HDPE)] [B: Linear low-density polyethylene (LLDPE)]** containing no plasticizers, fillers, extenders, reclaimed polymers, or chemical additives, except following:

1. Approximately 2 percent by weight of carbon black to resin for ultraviolet resistance.
2. Antioxidants and heat stabilizers, not to exceed 1.5 percent total by weight, may be added as required for manufacturing.

B. Furnish in rolled single-ply continuous sheets with no factory seams.

C. Sheet Thickness: **[A: Minimum values determined in accordance with ASTM D5199 and shall not include ridges of rough-surfaced [B: HDPE] [C: LLDPE] geomembrane.] [D:__mils.]**

D. Sheet Width: Minimum **[A: 15] [B: 22] [C:]** feet.

E. Roll Length: Longest that will be manageable and reduce field seams.

F. Rough-Surfaced **[A: HDPE] [B: LLDPE]** Geomembrane: Manufactured so that surface irregularities that produce specified friction are adequately fused into sheet or are extruded with sheet, on **[C: both sides] [D: one side]** of sheet. Texture is to be in addition to base thickness specified for sheet.

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G. **[A: Meet manufacturer's most recent published specifications and required minimum HDPE geomembrane values in this table.]**

Minimum Physical Properties for HDPE Geomembrane		
Property	**Required Value**	**Test Method**
Specific Gravity	0.940 to 0.936, g/cc; not more than 15% greater than base resin density	ASTM D792, Method A-1 or ASTM D1505
Smooth-Surface, HDPE Minimum Properties, Each Direction		
Tensile Stress at Yield	2.1 lb/in-width/mil thickness	ASTM D638
Elongation at Yield	12% minimum	
Thickness, Nominal, plus or minus 5%	**[A: 60 mil] [B: 80 mil] [C:]**	ASTM D5199
Puncture Resistance	1.25 lb/mil thickness	ASTM D4833
Tear Resistance	0.70 lb/mil thickness	ASTM D1004, Die C
Modulus of Elasticity	80,000 lb/sq in	ASTM D882, Method A or ASTM D638
Bonded Seam Strength in Shear	2 lb/in-width/mil thickness, min. and FTB	ASTM D6392
Bonded Seam Strength in Peel	1.2 lb/in-width/mil thickness, min. and FTB	ASTM D6392
Rough-Surfaced, HDPE Minimum Properties, Each Direction		
Thickness, min., for thinner areas of textured sheet	**[D: 57 mil] [E: 76 mil] [F:]**	ASTM D5199, Modified Note 2, or ASTM D5994
Tensile Stress at Yield	2 lb/mil thickness	ASTM D638
Elongation at Yield	12% plus or minus 3%	
Puncture Resistance	1 lb/mil thickness	ASTM D4833
Tear Resistance	0.70 lb/mil thickness	ASTM D1004, Die C
Angle of friction between rough-surfaced HDPE, & soil or geotextile	**[G:]**, min. (Note 1)	ASTM D5321, state conditions of test

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Minimum Physical Properties for HDPE Geomembrane		
Property	**Required Value**	**Test Method**
Brittleness Temperature	Minus 70º F, no cracks	ASTM D746 (Proc. B)
Coefficient of Linear Thermal Expansion	1.2 x 10^{-4} in/in/degree C	ASTM D696
Hydrostatic Resistance	7.5 lb/sq in/mil thickness	ASTM D751, Method A
Environmental Stress Crack	1,500 hours	ASTM D1693, Condition B (50ºC) and 10% Igepal Solution
Bonded Seam Strength in Shear	2 lb/in-width/mil thickness, min. & FTB	ASTM D 6392
Bonded Seam Strength in Peel	1.2 lb/in-width/mil thickness, min. & FTB	ASTM D6392
Water Absorption, Weight Change/Adap.	0.085% max.	ASTM D570

Notes:

1. Provide certified results for angle or coefficient of friction tests between rough-surfaced HDPE and actual soils and geotextiles to be used. Perform tests on Samples of similar length and width of 0.8- to 1-square foot minimum area. Submit test results to Engineer for review prior to shipment of rough-surfaced HDPE.
2. Commercially available micrometers may be used that have a 60-degree taper to a point with a radius of 1/32 inch. Engineer shall make enough measurements of thinner areas of textured sheet to develop statistical basis for thickness.

H. **[A: Meet manufacturer's most recent published specifications and required minimum LLDPE geomembrane values in this table.]**

Minimum Physical Properties for LLDPE Geomembrane		
Property	**Required Value**	**Test Method**
Specific Gravity	0.91 to 0.94, g/cc	ASTM D792, Method A-1 or ASTM D1505
Smooth-Surface, LLDPE Minimum Properties, Each Direction		
Tensile Stress at Break	3.8 lb/in-width/mil thickness, min.	ASTM D638

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Minimum Physical Properties for LLDPE Geomembrane		
Property	**Required Value**	**Test Method**
Elongation at Break	800%, min.	
Thickness, Nominal, plus or minus 10%	**[A: 40 mils] [B: 60 mils] [C:]**	ASTM D5199
Puncture Resistance	1.30 lb/mil thickness	ASTM D4833
Tear Resistance	0.55 lb/mil thickness	ASTM D1004, Die C
Bonded Seam Strength in Shear	1.5 lb/in-width/mil thickness, min. and FTB	ASTM D6392
Bonded Seam Strength in Peel	1.2 lb/in-width/mil thickness, min. and FTB	ASTM D6392
Rough-Surfaced, LLDPE Minimum Properties, Each Direction		
Thickness, min., for thinner areas of textured sheet	**[D: 36 mils] [E: 54 mil] [F:]**	ASTM D5199, Modified Note 2, or ASTM D 5994
Tensile Stress at Break	1.5 lb/mil thickness, min.	ASTM D638
Elongation at Break	250%, min.	
Puncture Resistance	1.2 lb/mil thickness, min.	ASTM D4833
Tear Resistance	0.55 lb/mil thickness, min.	ASTM D1004, Die C
Angle of friction between rough-surfaced LLDPE, & soil or geotextile	**[G:]**, min. (Note 1)	ASTM D5321, state conditions of test.
Brittleness Temperature	Minus 70º F, no cracks	ASTM D746 (Proc. B)
Hydrostatic Resistance	7.5 lb/sq in/mil thickness	ASTM D751, Method A
Bonded Seam Strength in Shear	1.5 lb/in-width/mil thickness, min. & FTB	ASTM D6392
Bonded Seam Strength in Peel	1.2 lb/in-width/mil thickness, min. & FTB	ASTM D6392

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Minimum Physical Properties for LLDPE Geomembrane		
Property	**Required Value**	**Test Method**
Notes: 1. Provide certified results for angle or coefficient of friction tests between rough-surfaced LLDPE and actual soils and geotextiles to be used. Perform tests on Samples of similar length and width of 0.8- to 1-square foot minimum area. Submit test results to Engineer for review prior to shipment of rough-surfaced LLDPE. 2. Commercially available micrometers may be used that have a 60-degree taper to a point with a radius of 1/32 inch. Engineer will make enough measurements of thinner areas of textured sheet to develop statistical basis for thickness.		

I. Extrudate for Fusion Welding of **[A: HDPE] [B: LLDPE]** Geomembranes: Formulated from the same resin as geomembrane and shall meet applicable physical property requirements.

2.03 SOIL STERILANT

A. **[A: As specified in Section 31 23 13, Subgrade Preparation.] [B: Pramitol as manufactured by Ciba-Geigy.] [C: .]**

2.04 BOOTS

A. Fabricated of same material as geomembrane sheets to fit around penetrations, without folds, stretching, or unsupported areas.

B. Flanges:

1. Angle: Match slope or bottom where penetration passes through liner.
2. Width: Minimum 2 feet, plus dimension of penetration.

2.05 SEALANT CAULKING

A. Two-component sealant formulated of 100 percent polyurethane elastomer, such as Elastuff 120 Mastic as supplied by United Paint and Coatings, Greenacre, WA.

B. Butyl rubber sealant such as Butylgrip Sealant, supplied by the Biddle Company, St. Louis, MO.

2.06 STAINLESS STEEL BANDS

A. As manufactured by Breeze Clamp Products, Saltsburg, PA.

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2.07 STAINLESS STEEL BATTENS

A. In conformance with ASTM A276, Type **[A: 316] [B:]**, Grade A.

1. Flat Bars: 2 inches wide by 1/4 inch thick.
2. Channel: 2 inches wide by 1/8 inch thick.

2.08 ALUMINUM CLAMP MATERIAL

A. In accordance with ASTM B211, Alloy 5052, Temper H32.

1. Strips: 2 inches wide by 1/4 inch thick.
2. Channel: 2 inches wide by 1/8 inch thick.

2.09 EPOXY ANCHOR SYSTEM

A. Anchor Rod: Conform to ASTM A193/A193M, Type 316 stainless steel threaded rod free of grease, oil, and other deleterious material.

B. Nuts: Stainless Steel, conform to ASTM A194/A194M, Type 316.

C. Washers: Flat, stainless steel, conforming to ASTM A194/A194M, Type 316.

D. Epoxy Adhesive:

1. Two-component, 100 percent solids, nonsag, paste, insensitive to moisture, designed to be used in adverse freeze/thaw environments.
2. Conform to ASTM C881/C881M, Type 1, Grade 3, Class A, B, or C.
3. Cure Temperature, Pot Life, and Workability: Compatible for intended use and environmental conditions.
4. Manufacturers and Products:
    a. ITW Ramset/Red Head, Wood Dale, IL; Epcon Ceramic 6 Epoxy Anchor System.
    b. Hilti, Inc., Tulsa, OK; HIT Doweling Anchor System (HIT HY 150).
    c. Powers Rawl, New Rochelle, NY; Power Fast Epoxy Injection Gel Cartridge System.
    d. Simpson Strong-Tie Co., Inc., Pleasanton, CA; Epoxy-Tie Adhesive ET22.
    e. Covert Operations, Inc., Long Beach, CA; CIA-Gel 7000 Epoxy Anchors.

2.10 NEOPRENE RUBBER PAD

A. Compression Strip Beneath Battens:

1. **[A: 2] [B:]** inches wide by 1/4 inch thick.

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2. 35 durometer to 45 durometer, in accordance with ASTM D2240 hardness.

B. Contact Cement: As recommended by neoprene rubber pad manufacturer.

C. Manufacturer: Aero Rubber Co., Inc., Bridgeview, IL.

2.11 PROTECTIVE FOAM

A. Medium to high-density rigid board.

B. Manufacturers and Products

1. General Plastics Manufacturing Corp, Tacoma, WA; Polyurethane Last-a-Foam.
2. Dow Chemical Corp., Midland, MI; Polyethylene Ethafoam.

2.12 CAST-IN-PLACE **[A: HDPE] [B: LLDPE]** EMBEDMENT

A. Properties: Compatible for attaching geomembrane materials by extrusion welding to provide watertight seal.

B. Manufacturers:

1. **[A: GSE Lining Technologies, Houston, TX.]**
2. **[B: Poly-Flex, Inc., Grand View, Texas.]**
3. **[C: GRU America, Georgetown, SC.]**

2.13 FACTORY TESTING

A. Interface Friction Testing:

1. Minimum peak and residual friction angles between geomembrane and adjacent materials shall be at least **[A:]** degrees as determined by ASTM D5321. Confining pressures should approximate loading conditions in field. Soil in contact with geomembrane shall be in consolidated, undrained state.
2. Test results shall include description of specimen size, supporting substrate conditions, soil installation method, unit weight, and moisture condition, normal loads used, and rate of strain.
3. **[B: Rough-Surfaced Geomembrane:**
   a. **Perform coefficient of interface friction tests between geomembrane and actual materials that will be in contact with it. Use Samples of similar length and width. Soil at geomembrane interface shall be consolidated-undrained material.**

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b. **Test Results: Include specimen size, supporting substrate, soil installation method and unit weight, soil moisture at molding and test, and rate of strain and normal loads.]**

PART 3 EXECUTION

3.01 PREPARATION

A. Geomembrane Inspection: During unwrapping visually inspect and mark each imperfection for repair.

B. Do not place geomembrane until condition of subgrade or geosynthetics installed is acceptable to Engineer.

C. Subgrade: Maintain in smooth, uniform, and compacted condition as specified in Section 31 23 13, Subgrade Preparation, during installation of geomembrane.

D. Concrete Surfaces in Contact with Geomembrane:

1. As specified in Section 03 30 00, Cast-in-Place Concrete, unless otherwise specified herein.
2. Provide smooth surface, free of projections, rough spots, voids, honeycomb, or other irregularities. Grind uneven concrete surface to which geomembrane is to be attached, flat and smooth. Round edges to minimum 1/2-inch radius.
3. Clean contact surfaces of dirt, dust, oil, curing compounds, and other coatings by sandblasting.

3.02 SOIL STERILANT

A. **[A: As specified in Section 31 23 13, Subgrade Preparation.] [B: In accordance with manufacturer's instructions.]**

B. **[A: Apply to prepared subgrade beneath liner and handle in strict accordance with manufacturer's recommendations.]**

3.03 WELDING UNITS

A. Single or double hot-wedge fusion seam welding.

B. Extrusion welding systems.

C. Hot-air welding is not acceptable.

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3.04 GEOMEMBRANE INSTALLATION

A. Do not install geomembrane or seam unless Contractor can demonstrate successful performance and test results showing seams meet strength specifications.

B. Protection:

1. Do not use geomembrane surfaces as work area for preparing patches, storing tools and supplies, or other uses. Use protective cover as work surface, if necessary.
2. Instruct workers about requirements for protection of geomembrane, such as, handling geomembrane material in high winds, handling of equipment, and walking on geomembrane surfaces. Shoes of personnel walking on geomembrane shall be smooth bonded sole or be covered with smooth type of overboot. Prohibit smoking, eating, or drinking in vicinity of geomembrane, placing heated equipment directly on geomembrane, or other activities that may damage geomembrane.
3. Do not operate equipment without spark arrestors in vicinity of geomembrane material nor place generators or containers of flammable liquid on geomembranes.
4. Protect from vehicle traffic and other hazards.
5. Keep free of debris during placement.
6. Prevent uplift, displacement, and damage by wind.
7. Only small rubber-tired equipment, with maximum tire inflation pressure of 5 pounds per square inch, shall be allowed directly on geomembrane, unless otherwise approved by Engineer. Demonstrate that equipment can be operated without damaging geomembrane.

C. Placement:

1. Miscellaneous products required for completion of geomembrane installation shall be in accordance with this specification and geomembrane manufacturer’s recommendations.
2. Reduce field seaming to the minimum amount possible. Horizontal seams on slopes will not be acceptable. Seams parallel to toe shall be at least 5 feet from toe. Align rough-sided sheets in manner that maximizes their frictional capabilities along slope.
3. Prevent wrinkles, folds, or other distress that can result in damage or prevent satisfactory alignment or seaming. Provide for factors such as expansion, contraction, overlap at seams, anchorage requirements, seaming progress, and drainage.

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4. Temporarily weight sheets with sandbags to anchor or hold them in position during installation. Use continuous holddowns along edges to prevent wind flow under sheet.
    a. Bag Fabric: Sufficiently close knit to preclude fines from working through bags.
    b. Bags: Contain not less than 40 pounds nor more than 60 pounds of sand having 100 percent passing No. 8 screen and shall be securely closed after filling to prevent sand loss.
    c. Do not use tires or paper bags, whether or not lined with plastic. Burlap bags, if used, shall be lined with plastic.
    d. Immediately remove damaged or improperly sealed bags from work area, and clean up spills.
5. Anchor perimeter of geomembrane as shown or as otherwise approved by Engineer. Anchor and seal geomembrane to structures, pipes, and other types of penetrations as shown.
6. Place overlying **[A: geotextile] [B: and] [C: soil cover]** immediately following completion of geomembrane installation and field testing as acceptable to Engineer.

D. Field Seams:

1. Wipe sheet contact surfaces clean to remove dirt, dust, moisture, and other foreign materials and prepare contact surfaces in accordance with seaming method accepted by Engineer.
2. Lap sheet edges to form seams. Adjust edges to be seamed and temporarily anchor to prevent wrinkling and shrinkage.
3. Seams shall not go through a boot. Locate seams minimum of 2 feet from boot.
4. Avoid seam intersections involving more than three thicknesses of geomembrane material. Offset seam intersections at least 2 feet. Extend seams through anchor trench to sheet edges.
5. Seal seam “T” intersections by removing excess material and extrusion welding lap joint.
6. Seam sheets together, using fusion-extrusion or hot-wedge welding system, equipment, and techniques.
7. Capping of Field Seams: Use 8-inch wide (minimum) cover strip of same thickness as geomembrane (and from same roll, if available). Position strip over center of field seam and weld to geomembrane using fillet weld each side, including copper wire as described above for spark testing.

E. Geomembrane Attachment to Flat Concrete Surfaces:

1. Concrete Anchors: Install in accordance with anchor manufacturer’s written instructions, and using manufacturer-supplied or manufacturer-recommended drills and equipment.

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2. Position and fit geomembrane to be free of wrinkles at locations of attachment.
3. Tighten anchor bolt nuts to uniformly deform rubber pad beneath battens 12 percent to 15 percent of total thickness of rubber pad to obtain watertight connection of geomembrane to concrete surface.
4. **[A: HDPE] [B: LLDPE]** Embedments:
    a. Coordinate with Section 03 30 00, Cast-in-Place Concrete, and supplier.
    b. Attach to forms by nailing strip every 18 inches to ensure flat surface is tight against form.
    c. Allow 1/4-inch to 3/8-inch spacing between butt joints to allow for thermal expansion before welding joints.
    d. Allow 6-inch spacing from walls or edges of concrete.
    e. Chamfer ends of butt joints or intersection joints to allow for extrusion welding seal of strip.
    f. On sloped or horizontal surfaces, embedments with air release holes may be pushed into poured concrete.
    g. Seal nail and air holes with extrudate prior to installing membrane.
    h. Make full perimeter weld of geomembrane to embedment to ensure maximum watertightness.

F. Boot Seals:

1. Preparation: Thoroughly clean contact surfaces.
2. Place boot around penetrations so flange is supported everywhere in full contact with subgrade, and is free of wrinkles.
3. Seal boot to surrounding geomembrane as specified for field seams using extrusion-welding methods.
4. Tighten steel clamping bands until neoprene rubber pads are compressed 12 percent to 15 percent of total pad thickness.

3.05 PLACING PRODUCTS OVER GEOMEMBRANE

A. Prior to placing material over geomembrane, notify Engineer. Do not cover installed geomembrane until after Engineer provides authorization to proceed.

B. Do not place granular materials on geomembrane where typical height of wrinkles is greater than 2 inches and spacing between wrinkles is less than 10 feet.

C. Do not place soil materials in manner that will cause wrinkles to fold over or become confined to form a vertical ridge.

D. Place soil materials when geomembrane is cool and contracted and wrinkles are minimized.

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E. If tears, punctures, or other geomembrane damage occurs during placement of overlying products, remove overlying products as necessary to expose damaged geomembrane, and repair damage as specified in Article Repairing Geomembrane.

F. Geomembrane installer shall remain available during placement of overlying products to repair geomembrane if damaged.

3.06 REPAIRING GEOMEMBRANE

A. Any geomembrane surface showing injury because of scuffing, penetration by foreign objects, or distress from rough subgrade shall be replaced or covered and sealed with an additional layer of geomembrane material of proper size.

B. Repair damage or rejected seams with pieces of flat and unwrinkled geomembrane material free from defects and seams. Patches shall be tightly bonded on completion of repair Work.

C. Patch shall be neat in appearance and of size **[A: 4] [B: 6] [C:]** inches larger in all directions than area to be repaired. Round corners of patch to minimum 1-inch radius.

D. Prepare contact surfaces and seam patch in accordance with paragraph Field Seams.

1. Pull and hold flat receiving surface in area to be patched.
2. Seal each patch by extrusion welding continuous bead along edge, with no free edge remaining.
    a. Vacuum box test each patch on completion.

3.07 FIELD QUALITY CONTROL

A. Prior to starting geomembrane installation and daily thereafter for installation on subgrade, geomembrane installer shall certify in duplicate that surface upon which geomembrane shall be installed is acceptable, on form located at end of section.

B. Identify each test by date of sample, date of test, sample location, name of individual who performed test, standard test method used, list of departures from standard test methods, at minimum.

C. In-Place Observation and Testing:

1. Visually inspect geomembrane sheets, seams, anchors, seals, and repairs for defects as installation progresses and again on completion.

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2. Depending on seam welding equipment used, test each seam and repair using vacuum testing device, spark testing device, or air channel pressure test for double wedge welded seams.
3. Perform testing in presence of Engineer.

D. Field Testing Equipment:

1. Tensiometer:
   a. Motor driven portable tensile tester with jaws capable of traveling at measured rate of 2 inches per minute (for HDPE) and 20 inches per minute (for LLDPE).
   b. Equip with gauge which measures force in unit pounds exerted between jaws.
   c. Minimum capacity of 500 pounds.
2. Vacuum Box: Conform to ASTM D5641.
3. High Voltage Spark Detector: Tinker and Rasor Holiday Detector, Model AP-W, set at 20,000 volts.

E. Field Seam Sampling:

1. Verify that seaming equipment and operators are performing adequately. Produce test seam samples at beginning of each shift for each seaming crew. In addition, if seaming has been suspended for more than 1/2 hour, or if breakdown of seaming equipment occurs, produce test seam samples prior to resuming seaming.
2. Sample Size: 12 inches wide plus seam width, and 30 inches long.
3. Nondestructive Sampling:
   a. For boots and seams that cannot be otherwise tested, insert copper wire for spark test at edge of overlapping sheet in extrudate of weld prior to filet welding. Position to within 1/8 inch of sheet edge.
   b. Frequency: Minimum one Sample per 500 feet of field seam or portion thereof, and minimum one Sample per seaming crew per 4-hour work period.
   c. Produce Samples using same materials, equipment, personnel, and procedures as field seams made at time of work in progress and under same conditions.
4. Destructive Sampling:
   a. Frequency: Determined by Engineer.
   b. Remove Samples from field seams at locations selected by Engineer.
   c. Repair field seams in accordance with repair procedures specified in these Specifications.

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5. Sample Identification:
    a. Number, date, and identify each sample as to personnel making seam and location of sample or location of field seam Work in progress at time Sample is made.
    b. Mark location of Sample, or location of field seam in progress at time sample is made, on panel/sheet layout drawing.
6. **[A: Contractor shall conform to the following testing requirements for nondestructive and destructive seam tests used to define quality of field seams:**
    a. **Perform shear and peel testing on portion of sample as specified hereinafter using approved field tensiometer.**
    b. **Send portion of sample by overnight service to approved Independent Testing Agency for verification of field test results.**
    c. **Archive a portion of sample for potential verification testing later.**
    d. **Independent Testing Agency shall provide preliminary test results by facsimile or other means no later than [B: 24] [C:] hours after Samples have been received from Contractor, unless otherwise approved by Engineer. Certified test results shall be provided no more than [D: 7] [E:] days after Samples have been received from Contractor.]**
7. Conform to ASTM D6392 and this specification.
    a. **[F: Seam]** testing for geomembrane includes strength tests, **[G: vacuum box testing,] [H: high voltage spark tests,] [I: air channel pressure tests,]** and probing.
    b. Leak testing includes **[J: water level leakage testing] [K: and] [L: electrical resistivity testing] [M: and] [N: tracer dye leakage testing]**.

F. Field Seam Strength Sample Testing:

1. General:
    a. Test each sample for seam peel and tensile strength.
    b. Save test samples, including specimens tested, until notified by Engineer relative to their disposal.
    c. Each sample that fails under test shall be shipped immediately by express delivery to Engineer for determination of corrective measures required.
2. Field Seam Acceptance Criteria: Seam strength equal to 90 percent of that of parent material. Parent material shall be tested in accordance with ASTM D638.
    a. **[A: Bonded Shear Strength of HDPE:**
        1) **In Shear: Minimum 2 pounds per inch width per mil thickness as determined in accordance with ASTM D6392.**

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2) **In Peel: Minimum 1.2 pounds per inch width per mil thickness as determined in accordance with ASTM D6392.]**

b. **[B: Bonded Shear Strength of LLDPE:**

1) **In Shear: Minimum 1.5 pounds per inch per mil thickness as determined by ASTM D6392.**

2) **In Peel: Minimum 1.2 pounds per inch per mil thickness as determined by ASTM D6392.]**

3. Test Failure: If sample fails, entire field seam from which it was taken shall be considered a failure and shall be rejected as a result of nonconformance with specification requirements. Comply with following corrective measures:

a. Nondestructive Sample Failure: Rerun field weld test using same sample. If that test passes, Engineer may assume error was made in first test and accept field seam. If second test fails, cap each field seam represented by failed sample and submit new test Sample made during capping procedure.

b. Destructive Sample Failure: Rerun field weld test using new sample from same seam. If that test passes, Engineer may assume error was made in first test and accept field seam. If second test fails, either cap field seam between two previous passed seam test locations that include failed seam or take another sample on each side of failed seam location (10 feet minimum), and test both. If both pass, cap field seam between two locations. If either fails, repeat process of taking samples for test. Each field seam shall be bounded by two passed test locations prior to acceptance.

G. Vacuum Box Testing of Geomembrane Welds:

1. Vacuum box test each of these types of welds: Fillet, extrusion lap, and single hot-wedge fusion lap.
2. Testing Procedures: Conforming to ASTM D5641.

H. High-Voltage Spark Testing of Fillet Welds:

1. Provide each seam to be tested with copper wires properly embedded in seam as shown and with provisions for electrical grounding to test equipment.
2. Pass spark tester along length of seam containing copper wire.
3. Presence of a visible spark along tested seam shall be evidence of a faulty seam.
4. Mark faulty areas for repair and retesting.

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I. Air Channel Pressure Testing of Double Hot-Wedge Seam:

1. Insert a needle with gauge in air space between welds. Pump air into space to **[A: 30] [B:]** psi and hold for 5 minutes.
2. At end of 5 minutes, depressurize seam by placing needle hole in air space between welds at opposite end of seam and observe gauge.
3. Seam is acceptable if seam maintains at least **[C: 27] [D:]** psi during 5-minute hold and pressure drops within 30 second of depressurization.
4. Seam is acceptable if seam maintains a minimum of **[E: 27] [F:]** psi. If pressure drops below **[G: 27] [H:]** psi during test period, or does not drop during 30-second depressurization period, repair needle holes and retest seam by same procedure or vacuum box test along entire length of seam.
5. Vacuum box test entire length of seam if second air pressure test fails.
   a. If no bubbles appear in vacuum box, lower weld will be considered defective and upper seam is acceptable.
   b. If bubbles appear in vacuum box, repair each defective area by extrusion welding and test again by vacuum box.
6. As alternative to vacuum box testing, apply soap solution to exposed seam edge while maintaining required air channel test pressure.
   a. If bubbles appear, mark, trim unbonded edge, and extrusion weld defective areas.
   b. If no bubbles appear and test pressure cannot be maintained, leak is judged to be in bottom or second seam.
7. If leak is judged to be in bottom seam, **[I: cap strip]** length of seam tested **[J: will be accepted]**.
8. Mark and repair needle holes.

J. Documentation:

1. Record Documents, include the following:
   a. Panel and sheet numbers.
   b. Seaming equipment and operator identification.
   c. Temperature and speed setting of equipment.
   d. Date seamed.
   e. Identity and location of each repair, cap strip, penetration, boot and sample taken from installed geomembrane for testing.

3.08 MANUFACTURER'S SERVICES

A. Provide authorized representative of geomembrane manufacturer onsite for technical supervision and assistance during the following:

1. Preparation and inspection of surfaces on which geomembrane is to be placed.
2. Inspection of geomembrane prior to installation.

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3. Installation of geomembrane.
4. Placement of cover over installed geomembrane.
5. Certification of Proper Installation.

3.09 CLEANUP

A. Clean up work area as the Work proceeds. Take particular care to ensure that no trash, tools, and other unwanted materials are trapped beneath geomembrane and that scraps of geomembrane material are removed from the work area prior to completion of installation.

3.10 SUPPLEMENT

A. The supplement listed below, following "End of Section," are a part of this Specification.

1. Geomembrane Installer's Certification of Subsurface Acceptability.

END OF SECTION

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GEOMEMBRANE INSTALLER'S CERTIFICATION
OF
SUBSURFACE ACCEPTABILITY

Geomembrane installer, _____
for **[A: ,] [B: Project,]** hereby certify that supporting surfaces are acceptable for installation of geomembrane, undersigned having personally inspected condition of **[C: existing and] [D: constructed] [E: prepared]** surfaces. This certification is for areas shown on Attachment **[F:]** or defined as follows:

_____

_____

_____

_____

Condition of supporting surfaces in defined area meets or exceeds minimum requirements for installation of **[G: geomembrane] [H:]**.

Signed: _____
(Representative of Geomembrane Installer)

_____
(Position)

Date: _____

Witness: _____

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SECTION 35 20 16.25
FABRICATED SLIDE GATES AND STOP LOGS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Water Works Association (AWWA): C561, Fabricated Stainless Steel Slide Gates.
2. American Water Works Association (AWWA): C562, Fabricated Aluminum Slide Gates.
3. ASTM International (ASTM):
   a. A193/A193M, Alloy-Steel and Stainless Steel Bolting Materials for High Temperature or High Pressure Service and Other Special Purpose Applications.
   b. A240/A240M, Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and General Applications.
   c. A276, Standard Specification for Stainless Steel Bars and Shapes.
   d. A380, Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.
   e. B209, Standard Specification for Aluminum and Aluminum Alloy Sheet and Plate.
   f. B308/B308M, Standard Specification for Aluminum-Alloy 6061-T6 Standard Structural Profiles.
4. National Electrical Manufacturers Association (NEMA): 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
5. NSF International (NSF):
   a. NSF/ANSI 61, Drinking Water System Components - Health Effects.
   b. NSF/ANSI 372, Drinking Water System Components - Lead Content.

1.02 DEFINITIONS

A. Self-Contained: The arrangement of gate operator, supported by gate frame, such that operating thrust loads are not applied external to the assembly.

B. Slenderness Ratio: The ratio of the maximum unsupported stem length to the stem cross-section radius of gyration.

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1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Make, model, weight, and horsepower of each equipment assembly.
   b. Manufacturer's catalog information, descriptive literature, specifications, and identification of materials of construction.
   c. Detailed structural, mechanical, and electrical drawings showing the equipment fabrications and interface with other items. Include dimensions, size, and locations of connections to other work, and weights of associated equipment associated therewith.
   d. Gate operator and stem calculations for each gate and service condition.
   e. Gate opening and closing thrust forces that will be transmitted to the support structure with operator at extreme positions and load.
   f. External utility requirements such as air, water, power, drain, etc., for each component.
   g. Functional description of internal and external instrumentation and controls to be supplied including list of parameters monitored, controlled, or alarmed.
   h. Power and control wiring diagrams, including terminals and numbers.
   i. Performance Test Procedures.
   j. Anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.

B. Informational Submittals:

1. Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements.
3. Special shipping, storage and protection, and handling instructions.
4. Manufacturer's written/printed installation instructions.
5. Routine maintenance requirements prior to plant startup.
6. Operation and Maintenance Data: As specified in Section 01 78 23, Operation and Maintenance Data.
7. Manufacturer's Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers' Field Services.
8. Service records for maintenance performed during construction.

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1.04 SYSTEM DESCRIPTION

A. Coordinate such that electric motor operators are fully assembled and tested, including motor, at the factory.

1.05 EXTRA MATERIALS

A. Furnish, tag, and box for shipment and storage the following spare parts and special tools:

Item	Quantity
Stem collars for all gate stems	One of each different size
Bronze lift nuts	One of each different size
Indicator lights	One dozen
Special tools required to maintain or dismantle	One complete set

B. Delivery: In accordance with Section 01 61 00, Common Product Requirements.

PART 2 PRODUCTS

2.01 GENERAL

A. Components and Materials in Contact with Water for Human Consumption: Comply with the requirements of the Safe Drinking Water Act and other applicable federal, state, and local requirements. Provide certification by manufacturer or an accredited certification organization recognized by the Authority Having Jurisdiction that components and materials comply with the maximum lead content standard in accordance with NSF/ANSI 61 and NSF/ANSI 372.

1. Use or reuse of components and materials without a traceable certification is prohibited.

2.02 SUPPLEMENTS

A. See supplements to this section for additional product information.

2.03 MATERIALS

A. Stainless Steel:

1. Plate, Sheet, and Strip: ASTM A240/A240M, Type 316L.
2. Bars and Shapes: ASTM A276, Type 316L.

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2.04 PERFORMANCE REQUIREMENTS

A. Leakage shall not exceed 0.1 gallon per minute per foot of gate periphery under either seating or unseating head conditions.

2.05 SLIDE GATES

A. Rising stem type, with assembly styles designated as follows:

1. Style A: Upward acting type for wall surface mounting on the concrete structures.
2. Style B: Upward acting type for mounting in channels with concrete embedded frame and invert.
3. Style C: Downward acting weir gate type with P-type invert seal for wall surface mounting on the concrete structures.
4. Style D: Downward acting weir gate type with invert “P” seal for embedded side frame mounting in concrete structures.

B. Guide Frames:

1. Stainless steel.
2. Vertical Guides: Design for maximum rigidity, and extend in one continuous piece from the gate invert to form posts for support of gate operators of self-contained gates. When guides extended above the operating floor, they shall be sufficiently strong so that no further reinforcements are required.
    a. Weight: Not less than 9 pounds per linear foot for stainless steel.
    b. Incorporate a replaceable UHMW polyethylene bearing strip in a retainer slot on the downstream side (unseating head side) of the gate.
3. Frame Invert: For flush bottom gate, furnish a neoprene insert to function as a seating surface for the gate disc.
    a. Weight: Not less than 9 pounds per linear foot for stainless steel.
4. Join vertical guide frames and invert with factory welded corners.
5. Size guided slot to provide a minimum disc engagement of 1 inch on each side.

C. Disc:

1. Disc Plate (Sliding Member): One-piece stainless steel plate. Reinforce as required so that the disc will not deflect more than 1/720 of the gate span, when the upstream liquid depth (seating head side) is as shown on the schedule and the downstream liquid depth is less than 1/2 inch.
2. Reinforce gate disc with one-piece stainless steel angles or channels welded to the disc plate. Bolted reinforcements will not be permitted.

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D. Operator Support Yoke:

1. For self-contained gate operators, attached to the vertical extensions of the guide frames.
2. Constructed from at least two stainless steel angles, or two other suitable shapes, and bolt in place to provide a rigid assembly.
3. Maximum Deflection: Not to exceed 1/4 inch under full operator applied loading.

E. Stems:

1. 1-inch minimum diameter, ASTM A276, Type 316 stainless steel.
2. Threads: Acme type with RMS surface roughness of 63 microinches or less on the flanks for manually operated gates and 32 microinches or less on the flanks for electrically operated gates. Extend threaded portion of stem 2 inches above operator when gate is in CLOSED position.
3. Ratio of the unsupported stem length to the radius of gyration, both in inches, shall not exceed 200.
4. Stems to withstand in compression, without damage, the thrust equal to at least 2-1/2 times the rated output of the hoisting mechanism, with a 40-pound effort applied to the handwheel or crank.
5. Design electric motor-driven floor stands to withstand at least 1.25 times the output thrust of the motor in the stalled condition.
6. Equip operating stems with cast iron, bushed stem guides, mounted on cast iron brackets; adjustable in two directions and spaced so that the L/r ratio does not exceed 200.
7. Adjustable stop collar for the CLOSED position.
8. Connect the stems to the disc plate with a yoke, bolted to the stem and welded to the disc.
9. Slide gates having a width greater than twice the height shall have dual stems. For downward opening weir type gates, locate stems near outside edges of gate.

F. Stem Covers:

1. Transparent plastic, vented pipe stem cover and cap.
2. Provide with OPEN/CLOSED designators with 1-inch graduations on clear mylar pressure sensitive, adhesive tape, suitable for outdoor application.

G. Manufacturers:

1. Aluminum:
   a. Rodney Hunt Co.
   b. H. Fontaine, Ltd.

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c. Whipps, Inc.
d. Hydro Gate Corp.

2. Stainless Steel:
   a. Rodney Hunt Co.
   b. H. Fontaine, Ltd.
   c. Whipps, Inc.
   d. Hydro Gate Corp.

2.06 GATE OPERATORS

A. General:

1. Components: Withstand a minimum of 250 percent of design torque or thrust at extreme operator positions without damage.
2. Mount at walkway level, 36 inches above floor, unless otherwise indicated or required.
3. Gear train and gate stem sections shall produce a self-locking drive train.
4. Lift Nuts: Internally threaded with cut or cold-rolled Acme threads corresponding to stem threading.
5. Roller Bearings: Ball-thrust or tapered above and below lift nut to support both opening and closing thrusts.
   a. Grease lubrication fittings for bearings.
   b. Input pinions with needle or ball bearings.
6. Lubrication: Furnish rising stem gates with an insert lubricator flange in lift, with grease fitting for greasing stem threads below stem nut.
7. Manual Operator Limit Switches:
   a. Mounted on an angle adjacent to stem and actuated through limit switch wands by stop collar.
   b. Single-pole, double-throw type, with contacts rated 5 amps at 120V ac.
   c. Provide two switches, one for gate full OPEN, and one for gate full CLOSED, where indicated.

B. Dual-Stem Gate Operators:

1. Enclosed, geared floor or bench stands.
2. Interconnect so operators will work as a unit from single point with crank lever or interconnecting electric operator.
3. Interconnecting Shafts:
   a. Stainless steel with flexible couplings at ends.
   b. Diameter sufficient to prevent sagging.
   c. Include flanged coupling to allow precision weir leveling.

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C. Type 1, Handwheel-Operated Bench Stands:

1. Direct drive.
2. Sealed, ball thrust, roller or needle bearing type and equipped with bronze lift nut, internally threaded with Acme threads.
3. Furnish mechanical seals at housing penetrations.
4. Handwheel and Baseplate: Cast iron or cast aluminum.
5. Manual Effort: Not to exceed 40 pounds.

D. Type 2, Crank-Operated Bench Stands:

1. Weatherproof housings, mounted on cast aluminum or cast-iron base to the top horizontal member of the slide gate frame as described under paragraph Operator Support Yoke.
2. Solid Bronze Lift Nut: Integrally threaded with Acme threads.
3. Ball Thrust or Tapered Roller Bearings:
    a. Locate above and below operating nut flange to support opening and closing thrusts.
    b. Include grease lubrication fittings and input pinions.
4. Manual Crank Effort: Not to exceed 40 pounds.
5. Suitable for portable electric drill operation after removal of hand crank.

E. Type 3, Geared Floor Stands:

1. Crank-operated, with weatherproof housings with solid bronze lift nut.
2. Mount on high-strength cast-iron pedestal or base.
3. Maximum manual crank effort to operate gate shall not exceed 40 pounds.
4. Lift Nut: Internally threaded with Acme threads.
5. Furnish ball thrust or tapered roller bearings above and below the lift nut to support both opening and closing thrusts.
    a. Grease lubrication fittings for bearings.
    b. Input pinions with needle or ball bearings.
    c. Mechanical seals at housing penetrations.
6. Suitable for portable electric drill operation after removal of hand crank.

F. Type 4, Electric Motor Operators:

1. 28-inch-high steel pedestal or direct yoke-mounted, totally enclosed weatherproof electric drive unit, and a totally enclosed gear box that operates a two-piece, bronze stem nut, which lifts the gate stem.
2. Gears: Heat treated alloy steel, supported throughout by antifriction ball or roller bearings and grease lubricated.
3. Automatic double-acting geared limit switches and double-acting torque switches.
    a. Gear directly to the operating gear train and shall be “in step” at all times, whether in motor or manual operation.

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b. Wire geared limit switches internally to stop the motor at the fully OPEN and fully CLOSED positions.
c. Wire torque switches internally so that, in the event of a mechanical overload in either direction, the motor will be stopped.

4. Equip with side mounted handwheel for manual operation.
   a. Include an automatic clutch to positively disengage the handwheel at any time the drive motor control is energized.
   b. Design handwheel operator so that failure of the motorized gearing will not prevent hand operation of the gate.
5. Drive Unit:
   a. TENV, 480-volt, three-phase electric motor as specified in Section 26 20 00, Low-Voltage AC Induction Motors, with integral OPEN/STOP/CLOSE weatherproof pushbuttons, reversing controller, 480/120-volt control power transformer, space heaters in the limit switches and in the control compartments, mechanical dial type position indicator, and transparent plastic pipe stem cover and cap, unless otherwise specifically noted on the Drawings.
   b. Furnish motor enclosure with drainage and breathing holes.
   c. Self-locking, with approximately 12 inches per minute gate travel speed, and a rated running torque equal to 20 percent of the motor starting torque at a rated running time of 15 minutes, without exceeding the allowable NEMA temperature rise for the insulation class used.
6. Operation: Drive the gate to its fully OPEN or CLOSED position when the OPEN or CLOSED pushbutton is depressed momentarily. Motor shall stop in mid-travel when the STOP button is depressed.
7. Controls: Furnish the following in accordance with operator control styles listed below and specified in Slide Gate Schedule:

Feature	Description
A	Local OPEN/STOP/CLOSE pushbutton station
B	End position limit switches; OPEN and CLOSED position switches shall be normally open contacts that close at the end position; contacts shall be dry and rated for 5 amps, 120V ac.
C	Continuous position output; provide transmitter to generate a 4 mA to 20 mA dc signal to an external loop in direct proportion to gate position; the transmitter shall be factory mounted in a NEMA 250, Type 4 enclosure. Transmitter shall be capable of driving an external load impedance of 350 ohms minimum.

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Feature	Description
D	LOCAL/REMOTE weatherproof selector switch and provisions for remote OPEN/STOP/CLOSE operation; remote commands will be by way of a four-wire circuit, as shown; motor operator shall impress the voltage required to read these contacts and shall go to the commanded position or stop when in the REMOTE mode. Provide auxiliary contact which closes when LOCAL/REMOTE switch is in REMOTE position.

a. Operator Control Styles:
   1) Style 1: Includes control feature A only.
   2) Style 2: Includes control features A and B.
   3) Style 3: Includes control features A, B, and D.
   4) Style 4: Includes control features A, B, C, and D

8. Manufacturers:
   a. Rotork Controls;
   b. Flowserve Limitorque;
   c. AUMA;
   d. Approved Equal.

G. Identification Tagging Requirements:

1. For each gate operator, 1-1/2-inch minimum diameter heavy brass tag, bearing the gate tag number shown in the schedule.
2. Attach the tags to the operator by soldered split key rings to that ring and tag cannot be removed. Use block type numbers and letters with 1/4-inch minimum high numbers and letters stamped on and filled with black enamel.

2.07 APPURTENANCES

A. Lifting Lugs: Furnish suitably attached for equipment assemblies and components weighing over 100 pounds.

B. Anchor Bolts: ASTM A193/A193M, Type 316 stainless steel sized by equipment manufacturer at least 1/2 inch in diameter, or as shown, and as specified in Section 05 50 00, Metal Fabrications.

C. Staff Gauges: For stainless steel, downward acting weir gates. Graduated in 1/4 inches and marked every inch and foot.

1. Manufacturer and Product: Stevens Water Monitoring Equipment; Porcelain Enameled Style C.

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2.08 SHOP/FACTORY FINISHING

A. Mechanically descale and passivate all weld burn and weld slag in accordance with ASTM A380 to provide uniform finish.

B. Coat all bare ferrous metal components as listed but not limited to: handwheels, actuators, and motors, in accordance with Section 09 90 00. Painting and Coating.

PART 3 EXECUTION

3.01 INSTALLATION

A. In accordance with the manufacturer's written instructions.

B. Disassemble factory assembled gate components before installation.

C. Field mount operators after installing gates.

D. Brace thimbles internally during concrete placement.

E. Accurately place anchor bolts using templates furnished by the manufacturer and as specified in Section 05 50 00, Metal Fabrications.

F. Lubricate stems before operating.

3.02 FIELD QUALITY CONTROL

A. Functional Tests: Conduct on each slide gate.

B. Field Finishes

1. Touch-up coated components in accordance to 09 90 00, Painting and Coating.

C. Performance Test:

1. Conduct on each slide gate.
2. Perform under actual or approved simulated operating conditions.
3. Test for a continuous 3-hour period without malfunction.
4. Adjust, realign, or modify units and retest if necessary.

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3.03 MANUFACTURER'S SERVICES

A. Manufacturer's Representative: Present at Site or classroom designated by **[A: Owner] [B:],** for minimum person-days listed below, travel time excluded:

1. **[C:]** person-days for **[D: installation assistance] [E: and] [F: inspection.]**
2. **[G:] person-days for [H: functional] [I: and] [J: performance]** testing and completion of Manufacturer's Certificate of Proper Installation.
3. **[K:]** person-days for prestartup classroom or Site training.
4. **[L:]** person-days for facility startup.
5. **[M:]** person-days for post-startup training [**N: of Owner's personnel.] [O: Training shall not commence until an accepted detailed lesson plan for each training activity has been reviewed by [P: Owner.] [Q: Engineer.] [R:]]**

B. See Section 01 43 33, Manufacturers' Field Services and Section 01 91 14, Equipment Testing and Facility Startup.

C. Provide manufacturer's representative at Site in accordance with Section 01 43 33, Manufacturers' Field Services, for installation assistance, inspection and certification of proper installation, equipment testing, startup assistance, and training of **[B: Owner's] [C:]** personnel for specified component, subsystem, equipment, or system.

3.04 SUPPLEMENTS

A. The supplement listed below, following "End of Section," is a part of this Specification.

1. Slide Gate Schedule.

END OF SECTION

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Slide Gate Schedule

Gate Tag Number	Description	Flow Stream	Gate Style	Opening Width (in)	Opening Hight (in)	Gate Height (in)	Design Operating Head (feet)	Seating Condition (feet)	Unseating Condition (feet)	Operator Type	Control Style
GTE28020101	Floc Basin 1 Influent Channel Gate	Raw Water	A	36	36						
GTE28020201	Floc Basin 1 Influent Channel Gate	Raw Water	A	36	36						
GTE28020301	Floc Basins 1&2 Influent Channel Separation Gate	Raw Water	A	36	36						
GTE36010801	Wet Well Isolation Gate 1	Finished Water	A								
GTE36010802	Wet Well Isolation Gate 2	Finished Water	A								
GTE36010803	Wet Well Isolation Gate 3	Finished Water	A								
GTE36010804	Wet Well Isolation Gate 4	Finished Water	A								
GTE36010805	Wet Well Isolation Gate 5	Finished Water	A								
GTE36010806	Wet Well Isolation Gate 6	Finished Water	A								
GTE36010901	Wet Well Drain Gate 1	Finished Water	A								
GTE36010902	Wet Well Drain Gate 2	Finished Water	A								
GTE42010001	Back Wash Waste Pond Isolation Gate 1	Liquid Residuals	A								
GTE42010002	Back Wash Waste Pond Isolation Gate 2	Liquid Residuals	A								
GTE44001001	Solids Drying Bed 1 Weir Gate	Decanted Water	C	48	90	66	8	8	8	Type 2	N/A
GTE44001002	Solids Drying Bed 2 Weir Gate	Decanted Water	C	48	90	66	8	8	8	Type 2	N/A

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SECTION 40 05 15
PIPING SUPPORT SYSTEMS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Society of Civil Engineers (ASCE): 7, Minimum Design Loads for Buildings and Other Structures.
2. American Society of Mechanical Engineers (ASME): B31.1, Power Piping.
3. ASTM International (ASTM):
   a. A123/A123M, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   b. A653/A653M, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvanealed) by the Hot-Dip Process.
   c. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
4. International Code Council (ICC):
5. International Building Code (IBC).
6. International Mechanical Code (IMC).
7. Manufacturers' Standardization Society (MSS):
   a. SP 58, Pipe Hangers and Supports—Materials, Design and Manufacture.
   b. SP 127, Bracing for Piping Systems Seismic-Wind-Dynamic Design, Selection, and Application.

1.02 DEFINITIONS

A. Wetted or Submerged: Submerged, less than 1 foot above liquid surface, below top of channel wall, under cover or slab of channel or tank, or in other damp locations.

1.03 SUBMITTALS

A. Action Submittals:

1. Catalog information and drawings of piping support system, locating each support, sway brace, seismic brace, hanger, guide, component, and anchor for piping. Identify support, hanger, guide, and anchor type by catalog number and Shop Drawing detail number.
2. Calculations for each type of pipe support, attachment and anchor.

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3. Revisions to support systems resulting from changes in related piping system layout or addition of flexible joints.
4. Seismic anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.

B. Informational Submittals:

1. Seismic anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Component and attachment testing seismic certificate of compliance as required by Section 01 45 33, Special Inspection, Observation, and Testing.
3. Maintenance information on piping support system.

1.04 DESIGN REQUIREMENTS

A. General:

1. Design, size, and locate piping support systems throughout facility, whether shown or not.
2. Piping Smaller than 30 Inches: Supports are shown only where specific types and locations are required; additional pipe supports may be required.
3. Piping 30 Inches and Larger: Support systems have been designed for piping shown.
4. Meet requirements of MSS SP 58 and ASME B31.1 or as modified by this section.

B. Pipe Support Systems:

1. Design pipe support systems for gravity and thrust loads imposed by weight of pipes or internal pressures, including insulation and weight of fluid in pipes.
2. Seismic loads in accordance with governing codes **[A: and as shown on Structural General Drawings]**.
3. Wind loads in accordance with governing codes **[B: and as shown on Structural General Drawings]**.
4. Maximum Support Spacing and Minimum Rod Size: In accordance MSS SP 58 Table 3 and Table 4.
    a. Ductile-iron Pipe 8 Inches and Under: Maximum span limited to that for standard weight steel pipe for water service.
    b. Ductile-iron Pipe 10 Inches and Larger: Maximum span limited to 20 feet.
5. **[A: Electrical Conduit Support: Include in design of framing support system.]**

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C. Anchoring Devices: Design, size, and space support anchoring devices, including anchor bolts, inserts, and other devices used to anchor support, to withstand shear and pullout loads imposed by loading and spacing on each particular support.

D. Vertical Sway Bracing: 10-foot maximum centers or as shown.

E. Existing Support Systems: Use existing supports systems to support new piping only if Contractor can show they are adequate for additional load, or if they are strengthened to support additional load.

PART 2 PRODUCTS

2.01 GENERAL

A. When specified items are not available, fabricate pipe supports of correct material and to general configuration indicated.

B. Special support and hanger details may be required for cases where standard catalog supports are not applicable.

C. Materials: In accordance with Table 1 and Table 2, attached as Supplements at end of section.

2.02 HANGERS

A. Clevis: MSS SP 58, Type 1:

1. Anvil; Figure 260 for steel pipe and Figure 590 for ductile-iron pipe, sizes 1/2 inch through 30 inches.
2. Insulated Steel Pipe: Anvil; Figure 260 with insulated saddle system (ISS), sizes 1/2 inch through 16 inches.
3. B-Line; Figure B3100, sizes 1/2 inch through 30 inches.

B. Adjustable Swivel Split-Ring Pipe Clamp: MSS SP 58, Type 6:

1. Anvil; Figure 104, sizes 3/4 inch through 8 inches.
2. B-Line; Figure B3171, sizes 3/4 inch through 8 inches.

C. Steel Yoke Pipe Rolls and Roller Supports: MSS SP 58, Type 41 or Type 43:

1. Anvil; Figure 181 for sizes 2-1/2 inches through 24 inches, and Figure 171 for sizes 1 inch through 30 inches.
2. B-Line; Figure B3110 for sizes 2 inches through 24 inches and Figure B3114 for 30 inches.

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D. Pipe Rollers and Supports: MSS SP 58, Type 44:

1. Anvil; Figure 175, sizes 2 inches through 30 inches.
2. B-Line; Figure B3120, sizes 2 inches through 24 inches.

2.03 WALL BRACKETS, SUPPORTS, AND GUIDES

A. Welded Steel Wall Bracket: MSS SP 58, Type 33 (heavy-duty):

1. Anvil; Figure 199, 3,000-pound rating.
2. B-Line; Figure B3067, 3,000-pound rating.

B. Adjustable “J” hanger MSS SP 58, Type 5:

1. Anvil; Figure 67, sizes 1/2 inch through 8 inches.
2. B-Line; Figure B3690, sizes 1/2 inch through 8 inches.

C. Offset Pipe Clamp: Anvil; Figure 103, sizes 3/4 inch through 8 inches.

D. Channel Type:

1. Unistrut.
2. Anvil; Power-Strut.
3. B-Line; Strut System.
4. Aickinstrut (FRP).

2.04 PIPE SADDLES

A. Provide 90-degree to 120-degree pipe saddle for pipe 6 inches and larger with baseplates drilled for anchors bolts.

1. In accordance with Standard Detail 4005-515.
2. Sizes 20 inches though 60 inches, Piping Technology & Products, Inc.; Fig. 2000.

B. Saddle Supports, Pedestal Type:

1. Minimum standard weight pipe stanchion, saddle, and anchoring flange.
2. Nonadjustable Saddle: MSS SP, Type 37 with U-bolt.
   a. Anvil; Figure 259, sizes 4 inches through 36 inches with Figure 63C base.
   b. B-Line; Figure B3095, sizes 1 inch through 36 inches with B3088S base.

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3. Adjustable Saddle: MSS SP 58, Type 38 without clamp.
    a. Anvil; Figure 264, sizes 2-1/2 inches through 36 inches with Figure 62C base.
    b. B-Line; Figure B3092, sizes 3/4 inch through 36 inches with Figure B3088S base.

2.05 CHANNEL TYPE SUPPORT SYSTEMS

A. Channel Size: 12-gauge, 1-5/8-inch wide minimum steel, or 1-1/2-inch wide, minimum FRP.

B. Members and Connections: Design for loads using one-half of manufacturer's allowable loads.

C. Fasteners: Vinyl ester fiber, polyurethane base composite nuts and bolts, or encapsulated steel fasteners.

D. Manufacturers and Products:

1. B-Line; Strut System.
2. Unistrut.
3. Anvil; Power-Strut.
4. Aickinstrut (FRP System).
5. Enduro-Durostrut (FRP Systems).

2.06 FRP PIPE SUPPORTS SYSTEMS

A. General:

1. FRP with UV additive, protective veil, and vinyl ester resins resistance to chemicals listed in Supplement at end of section.
2. Fire Retardant: ASTM E84.
3. Include hangers, rods, attachments, and fasteners.

B. Clevis Hangers:

1. Factor of Safety: 3 to 1.
2. Minimum Design Load: 200 pounds.

C. Design:

1. Design pipe supports spacing, hanger rod sizing based upon manufacturer's recommendations.
2. Identify and highlight nonFRP fasteners or components in Shop Drawing.

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D. Manufacturers:

1. Aickinstrut.
2. Enduro.
3. Century Composite.

2.07 PIPE CLAMPS

A. Riser Clamp: MSS SP 58, Type 8.

1. Anvil; Figure 261, sizes 3/4 inch through 24 inches.
2. B-Line; Figure B3373, sizes 1/2 inch through 30 inches.

2.08 ELBOW AND FLANGE SUPPORTS

A. Elbow with Adjustable Stanchion: Sizes 2 inches through 18 inches, Anvil; Figure 62C base.

B. Elbow with Nonadjustable Stanchion: Sizes 2-1/2 inches through 42 inches, Anvil; Figure 63A or Figure 63B base.

C. Flange Support with Adjustable Base: Sizes 2 inches through 24 inches, Standon; Model S89.

2.09 INTERMEDIATE PIPE GUIDES

A. Type: Hold down pipe guide.

1. Manufacturer and Product: B-Line; Figure B3552, 1-1/2 inches through 30 inches.

B. Type: U-bolts with double nuts to provide nominal 1/8-inch to 1/4-inch clearance around pipe; MSS SP 58, Type 24.

1. Anvil; Figure 137 and Figure 137S.
2. B-Line; Figure B3188 and Figure B3188NS.

2.10 PIPE ALIGNMENT GUIDES

A. Type: Spider.

B. Manufacturers and Products:

1. Anvil; Figure 255, sizes 1/2 inch through 24 inches.
2. B-Line; Figure B3281 through Figure B3287, sizes 1/2 inch through 24 inches.

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2.11 PIPE ANCHORS

A. Type: Anchor chair with U-bolt strap.

B. Manufacturer and Product: B-Line; Figure B3147A or Figure B3147B.

2.12 SEISMIC RESTRAINTS

A. Solid pipe bracing attachment to pipe clevis with clevis cross brace and angle rod reinforcement.

B. Manufacturers:

1. Mason Industries.
2. B-Line.
3. Anvil.

2.13 ACCESSORIES

A. Anchor Bolts:

1. Size and Material: **[A: Sized by Contractor for required loads,] [B: 1/2-inch minimum diameter,]** and as specified in Section 05 50 00, Metal Fabrications.
2. Bolt Length (Extension Above Top of Nut):
   a. Minimum Length: Flush with top of nut preferred. If not flush, shall be no more than one thread recessed below top of nut.
   b. Maximum Length: No more than a full nut depth above top of nut.

B. Dielectric Barriers:

1. Plastic coated hangers, isolation cushion, or tape.
2. Manufacturer and Products:
   a. B-Line; B1999 Vibra Cushion.
   b. B-Line; Iso Pipe, Isolation Tape.

C. Insulation Shields:

1. Type: Galvanized steel or stainless steel, MSS SP 58, Type 40.
2. Manufacturers and Products:
   a. Anvil; Figure 167, sizes 1/2 inch through 24 inches.
   b. B-Line; Figure B3151, sizes 1/2 inch through 24 inches.

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D. Welding Insulation Saddles:

1. Type: MSS SP 58, Type 39.
2. Manufacturers and Products:
    a. Anvil; Figure Series 160, sizes 1 inch through 36 inches.
    b. B-Line; Figure Series B3160, sizes 1/2 inch through 24 inches.

E. Plastic Pipe Support Channel:

1. Type: Continuous support for plastic pipe and to increase support spacing.
2. Manufacturer and Product: B-Line; Figure Series B3106V, sizes 1/2 inch through 6 inches with Figure B3106 Vee bottom hanger.

F. Hanger Rods, Clevises, Nuts, Sockets, and Turnbuckles: In accordance with MSS SP 58.

G. Attachments:

1. I-Beam Clamp: Concentric loading type, MSS SP 58, Type 21, Type 28, Type 29, or Type 30, which engage both sides of flange.
2. Concrete Insert: MSS SP 58, Type 18, continuous channel insert with load rating not less than that of hanger rod it supports.
3. Welded Beam Attachment: MSS SP 58, Type 22.
    a. Anvil; Figure 66.
    b. B-Line; Figure B3083.
4. U-Channel Concrete Inserts: As specified in Section 05 50 00, Metal Fabrications.
5. Concrete Attachment Plates:
    a. Anvil; Figure 47, Figure 49, or Figure 52.
    b. B-Line; Figure B3084, Figure B3085, or Figure B3086.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:

1. Install support systems in accordance with MSS SP 58, unless shown otherwise.
2. Install pipe hanger rods plumb, within 4 degrees of vertical during shut down, start up or operations.
3. Support piping connections to equipment by pipe support and not by equipment.
4. Support large or heavy valves, fittings, and appurtenances independently of connected piping.

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5. Support no pipe from pipe above it.
6. Support pipe at changes in direction or in elevation, adjacent to flexible joints and couplings, and where shown.
7. Do not use adhesive anchors for attachment of supports to ceiling or walls.
8. Do not install pipe supports and hangers in equipment access areas or bridge crane runs.
9. Brace hanging pipes against horizontal movement by both longitudinal and lateral sway bracing and to reduce movement after startup.
10. Install lateral supports for seismic loads at changes in direction.
11. Install pipe anchors where required to withstand expansion thrust loads and to direct and control thermal expansion.
12. Repair mounting surfaces to original condition after attachments are completed.

B. Standard Pipe Supports:

1. Horizontal Suspended Piping:
   a. Single Pipes: Clevis hangers or adjustable swivel split-ring.
   b. Grouped Pipes: Trapeze hanger system.
2. Horizontal Piping Supported from Walls:
   a. Single Pipes: Wall brackets, or attached to wall, or to wall mounted framing with anchors.
   b. Stacked Piping: Wall mounted framing system and “J” hangers acceptable for pipe smaller than 3-inch.
   c. Pipe clamp that resists axial movement of pipe through support is not acceptable. Use pipe rollers supported from wall bracket.
3. Horizontal Piping Supported from Floors:
   a. Saddle Supports:
      1) Pedestal Type, elbow and flange.
      2) Provide minimum 1-1/2-inch grout beneath baseplate.
   b. Floor Mounted Channel Supports:
      1) Use for pipe smaller than 3-inch running along floors and in trenches at pipe elevations lower than can be accommodated using pedestal pipe supports.
      2) Attach channel framing to floors with baseplate on minimum 1-1/2-inch nonshrink grout and with anchor bolts.
      3) Attach pipe to channel with clips or pipe clamps.
   c. Concrete Cradles: Use for pipe larger than 3 inches along floor and in trenches at pipe elevations lower than can be accommodated using stanchion type.
4. Insulated Pipe:
   a. Pipe hanger and support shall be on outside of insulation. Do not enclose within insulation.

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b. Provide precut 120-degree sections of rigid insulation (minimum length same as shield), shields and oversized hangers or insulated saddle system (ISS).
c. Wall-mounted pipe clips not acceptable for insulated piping.

5. Vertical Pipe: Support with wall bracket and elbow support, or riser clamp on floor penetration.

C. Standard Attachments:

1. New Concrete Ceilings: Concrete inserts, concrete attachment plates, or concrete anchors as limited below:
   a. Single point attachment to ceiling allowed only for 3/4-inch rod and smaller (8 inches and smaller pipe).
   b. Where there is vibration or bending considerations, do not connect a single pipe support hanger rod directly to a drilled concrete anchor (single point attachment) regardless of size.
      1) These lines include air operated diagram pumps and other lines, if any, as identified below:
         a) **[A: .]**
2. Existing Concrete Ceilings: Channel type support with minimum of two anchor points, concrete attachment plates or concrete anchors as limited below:
   a. Single point attachment to ceiling is allowed only for 3/4-inch rod and smaller (8 inches and smaller pipe).
   b. Where there is vibration or bending considerations do not connect a single pipe support hanger rod directly to a drilled concrete anchor (single point attachment) regardless of size.
      1) These lines include air operated diagram pumps and other lines, if any, as identified below:
         a) **[B: .]**
3. Steel Beams: I-beam clamp or welded attachments.
4. Wooden Beams: Lag screws and angle clips to members not less than 2-1/2 inches thick.
5. Concrete Walls: Concrete inserts or brackets or clip angles with concrete anchors.
6. Concrete Beams: Concrete inserts, or if inserts are not used attach to vertical surface similar to concrete wall. Do not drill into beam bottom.

D. Saddles for Steel or Concrete Pipe: Provide 90-degree to 120-degree pipe saddle for pipe sizes 6 inches and larger when installed on top of steel or concrete beam or structure, pipe rack, trapeze, or where similar concentrated point supports would be encountered.

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E. Intermediate and Pipe Alignment Guides:

1. Provide pipe alignment guides, or pipe supports that provide same function, at expansion joints and loops.
2. Guide pipe on each side of expansion joint or loop at 4 pipe and 14 pipe diameters from each joint or loop.
3. Install intermediate guides on metal framing support systems not carrying pipe anchor or alignment guide.

F. Accessories:

1. Insulation Shield: Install on insulated piping with oversize rollers and supports.
2. Welding Insulation Saddle: Install on insulated steel pipe with oversize rollers and supports.
3. Dielectric Barrier:
   a. Provide between painted or galvanized carbon steel members and copper or stainless steel pipe or between stainless steel supports and nonstainless steel ferrous metal piping.
   b. Install rubber wrap between submerged metal pipe and oversized clamps.

3.02 FIELD FINISHING

A. Paint atmospheric exposed surfaces hot-dip galvanized steel components as specified in Section 09 90 00, Painting and Coating.

3.03 SUPPLEMENTS

A. The supplements listed below, following “End of Section,” are a part of this specification:

1. Table 1: Nonchemical Areas.
2. Table 2: Chemical Areas.

END OF SECTION

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Table 1 Nonchemical Areas	
Exposure Conditions	**Support Material**
Office Areas	Galvanized steel or precoated steel, plastic coated hangers for uninsulated copper or stainless steel piping
Shops and Warehouse Areas	Galvanized steel or precoated steel, plastic coated hangers for uninsulated copper or stainless steel piping
Pipe Galleries	Galvanized steel or precoated steel, plastic coated hangers for uninsulated copper or stainless steel piping
Headworks	Stainless steel or FRP
Process Areas: High Humidity or Hydrogen sulfide **[A: In rooms _____ or areas _____]**	Stainless steel or FRP
Process Areas: Wetted or Submerged	Stainless steel or FRP
[B: Pipes conveying chemicals listed in Table 2]	**[C: Provide with corresponding support per Table 2.]**

Notes:

1. Precoated steel to be fusion bonded epoxy or vinyl copolymer (Plastisol).
2. Stainless steel to be Type 304.
3. Galvanized steel to be per ASTM A653/A653M, Class G90, or hot-dip galvanized after fabrication to ASTM A123/A123M.
4. Do not use galvanized steel or aluminum where lime dust can accumulate on these surfaces.

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Table 2 Chemical Areas		
Exposure Conditions	**Support for Direct Exposure**	**Support for Remote Exposure**
Alum	FRP	Precoated steel
Aqua Ammonia	Stainless steel	Precoated steel
Coagulants	FRP	Precoated steel or galvanized steel
Ferric Chloride	FRP	Precoated steel
Ferric Sulfate	FRP	Precoated steel
Hydrofluorosilic Acid	FRP	Precoated steel
Lime	Stainless steel, FRP, precoated steel	Stainless steel, FRP, precoated steel
Methanol	Galvanized steel	Galvanized steel
Polymers	FRP	Precoated steel
Potassium Permanganate	Precoated steel	Precoated steel
Powdered Activated Carbon	Precoated steel	Precoated steel
Sodium Carbonate	Stainless steel	Precoated steel
Sodium Hydroxide	Stainless steel	Precoated steel
Sodium Hypochlorite	FRP	Precoated steel
Sulfuric Acid	Stainless steel	Precoated steel

Notes:

1. Direct exposure includes entire area within containment area; area within 20 feet horizontal and 10 feet vertical of chemical pumps or chemical mixing stations; or as specified.
2. Remote exposure is area beyond area defined as direct exposure, but within designated building.
3. Precoated steel to be fusion bonded epoxy or vinyl copolymer (Plastisol).
4. Stainless steel to be Type 304.
5. Galvanized steel to be per ASTM A653/A653M, Class G90, or hot-dip galvanized after fabrication to ASTM A123/A123M.
6. Do not use galvanized steel or aluminum where lime dust can accumulate on these surfaces.

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SECTION 40 05 33
PIPE HEAT TRACING

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Factory Mutual.
2. Institute of Electrical and Electronics engineers, Inc (IEEE): 515, Testing, Design, Installation and Maintenance of Electrical Resistance Heat Tracing for Industrial Applications.
3. National Electrical Manufacturers' Association (NEMA): 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
4. Underwriters Laboratories, Inc. (UL).

1.02 SUBMITTALS

A. Action Submittals:

1. Manufacturer's descriptive literature.
2. Plastic Pipe Installations: Output adjustment factors for heating tape for the services indicated.
3. Pipe heat loss calculations for each pipe size to be heat traced.

PART 2 PRODUCTS

2.01 SYSTEM DESIGN REQUIREMENTS

A. Design Heating Load:

1. Heating load to be calculated based upon a 75 degree F delta, 20 mph wind if pipes are located outdoors, insulation as specified in Section 40 42 13, Process Piping Insulation, pipe as specified in Section 40 27 00, Process Piping—General, and shall include a 10 percent safety factor.
2. Heat loss calculations shall be based on IEEE 515, Equation 1, Page 19.

2.02 ELECTRICAL HEATING TAPE

A. Cable: Self-limiting, parallel circuit construction consisting of continuous inner core of variable resistance conductive heating material between two parallel copper bus wires. Provide tinned copper braid for PVC, FRP, and stainless steel pipe applications.

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B. UL Listing: Listed as self-limiting pipe tracing material for pipe freeze protection application in ordinary conditions.

C. Maximum Maintenance Temperature: 150 degrees F (65 degrees C).

D. Maximum Intermittent Temperature: 185 degrees F (85 degrees C).

E. Service Voltage: As indicated by branch circuits provided for heat tracing on the Drawings.

F. Manufacturers and Products:

1. Raychem; BTV-CR.
2. Thermon; BSX.
3. Nelson; CL1-J1 or L1-J1.

2.03 CONNECTION SYSTEM

A. Rating: NEMA 250, Type 4 and Factory Mutual approved.

B. Operating Monitor Light: Furnish with each circuit power connection kit to indicate when heat tracing is energized.

C. Manufacturers and Products:

1. Power Connection Kit:
   a. Raychem; JBS-100.
   b. Thermon; PCA-1-SR or DP-L.
   c. Nelson; PLT-BC.
2. Splice Kit:
   a. Raychem; S-150.
   b. Thermon; PCS-1-SR.
   c. Nelson; PLT-BS.
3. Tee Kit:
   a. Raychem; T-100.
   b. Thermon; DS-S.
   c. Nelson; PLT-BY.
4. End Seal Kit:
   a. Raychem; E-150.
   b. Thermon; DE-S.
   c. Nelson; LT-ME.
5. Lighted End Seal Kit:
   a. Raychem; E-100-L.
   b. Thermon; DLS.
   c. Nelson; LT-L.

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2.04 SECURING TAPE

A. Plastic Piping Systems:

1. Type: Aluminum foil coated adhesive tape.
2. Manufacturers and Products:
   a. Raychem; AT-180.
   b. Thermon; AL-20P.
   c. Nelson; AT-50.

B. Metallic Piping Systems:

1. Type: Glass or polyester cloth pressure sensitive tape.
2. Manufacturers and Products:
   a. Raychem; GS54 or GT66.
   b. Thermon; PF-1.
   c. Nelson; GT-6 or GT-60.

2.05 PIPE MOUNTED THERMOSTAT

A. Type: Fixed, nonadjustable, set at 40 degrees F.

B. Sensor: Fluid-filled with 3-foot capillary.

C. Enclosure: Glass-filled nylon, NEMA 250, Type 4X weatherproof with gasketed lid.

D. Switch: SP-ST, UL listed, rated 22 amps, 120 to 240V ac.

E. Manufacturers and Products:

1. Raychem; DigiTrace Model AMC-F5.
2. Thermon; E4X-1.
3. Raychem; DigiTrace Model E507S-LS for hazardous areas.
4. Thermon; E7-25325 for hazardous areas.

2.06 AMBIENT THERMOSTAT

A. Type: Adjustable setting (15 to 140 degrees F).

B. Sensor: Fluid-filled probe.

C. Enclosure: Epoxy-coated NEMA 250, Type 4X aluminum enclosure with exposed hardware of stainless steel.

D. Switch: SP-DT, UL or FM listed, rated 22 amps, 125 to 250V ac.

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E. Manufacturers and Products:

1. Raychem; DigiTrace Model AMC-1A.
2. Thermon; B4X-15140.
3. Raychem; DigiTrace Model AMC-1H for hazardous areas.
4. Thermon; B7-15140 for hazardous areas.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:

1. Install in accordance with the manufacturer's instructions and recommended practices.
2. Provide insulation as specified in Section 40 42 13, Process Piping Insulation, over all pipe heat tracing.
3. Ground metallic structures or materials used for support of heating cable or on which it is installed in accordance with applicable codes.
4. Wiring between power connection points of heat tracing cable branch lines shall be provided by heat tracing system supplier.
5. Provide end of circuit pilot lights on heat tracing circuits for buried piping.

B. Electrical Heating Tape:

1. Determine required length of electrical heating tape by considering length of circuit, number and type of fittings and fixtures, design heating load, and heating tape output.
2. Where design heating load exceeds heating tape capacity, install by spiraling.
3. Derate heating tape capacity when installed on plastic piping.
4. Install on services as follows:

Service	Piping Material	Location
RW	CLDI	Facility 300 Exterior
W1, PW	CLDI	Yard Hydrants
USL	CLDI	Facility 300 Exterior
SLG	CLDI	Facility 420 Exterior
SA	PVC, SCH 80	Facility 360 Exterior

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Service	Piping Material	Location
EVD	CLDI	Facility 460 Exterior
RCY	CLDI	Facility 460 Exterior

5. Install additional heating tape at bolted flanges, valves, pipe supports, and other fittings and fixtures as recommended by supplier, but not less than the following:

Item	Heating Tape Length (min. feet)
Bolted flanges (per pair)	Two times pipe diameter
Valves	Four times valve length
Pipe hanger or support penetrating insulation	Three times pipe diameter

C. Heat Tracing Circuits: Limit individual lengths of heat tracing circuits such that maximum single circuit capacity is 20 amps when starting the circuit at 40 degrees F. Provide multiple 20-amp circuits as required at individual heat tracing locations.

D. Thermostats:

1. Install in accordance with manufacturer's instructions and as approved by Engineer.
2. For each group of heat traced circuit, install one ambient thermostat.

3.02 FIELD QUALITY CONTROL

A. Test each circuit with 500-volt insulation tester between circuit and ground with neutrals isolated from ground.

1. Insulation Resistance: Minimum 1,000 megohms per 1,000 feet.

END OF SECTION

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SECTION 40 27 00
PROCESS PIPING—GENERAL

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section and any supplemental Data Sheets:

1. American Petroleum Institute (API): SPEC 5L, Specification for Line Pipe.
2. American Society of Mechanical Engineers (ASME):
   a. Boiler and Pressure Vessel Code, Section IX, Qualification Standard for Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators.
   b. B1.20.1, Pipe Threads, General Purpose (Inch).
   c. B16.1, Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250.
   d. B16.3, Malleable Iron Threaded Fittings Classes 150 and 300.
   e. B16.5, Pipe Flanges and Flanged Fittings NPS 1/2 through NPS 24 Metric/Inch Standard.
   f. B16.9, Factory-Made Wrought Buttwelding Fittings.
   g. B16.11, Forged Fittings, Socket-Welding and Threaded.
   h. B16.15, Cast Copper Alloy Threaded Fittings Classes 125 and 250.
   i. B16.21, Nonmetallic Flat Gaskets for Pipe Flanges.
   j. B16.22, Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.
   k. B16.24, Cast Copper Alloy Pipe Flanges and Flanged Fittings Classes 150, 300, 600, 900, 1500, and 2500.
   l. B16.25, Buttwelding Ends.
   m. B16.42, Ductile Iron Pipe Flanges and Flanged Fittings Classes 150 and 300.
   n. B31.3, Process Piping.
   o. B31.9, Building Services Piping.
   p. B36.10M, Welded and Seamless Wrought Steel Pipe.
3. American Society for Nondestructive Testing (ASNT): SNT-TC-1A, Recommended Practice for Personal Qualification and Certification in Nondestructive Testing.
4. American Water Works Association (AWWA):
   a. C104/A21.4, Cement-Mortar Lining for Ductile-Iron Pipe and Fittings.
   b. C105/A21.5, Polyethylene Encasement for Ductile-Iron Pipe Systems.

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c. C110/A21.10, Ductile-Iron and Gray-Iron Fittings.
d. C111/A21.11, Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
e. C115/A21.15, Flanged Ductile-Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges.
f. C151/A21.51, Ductile-Iron Pipe, Centrifugally Cast.
g. C153/A21.53, Ductile-Iron Compact Fittings.
h. C207, Steel Pipe Flanges for Waterworks Service, Sizes 4 In. Through 144 In. (100 mm Through 3,600 mm).
i. C216, Heat-Shrinkable Cross-Linked Polyolefin Coatings for Steel Water Pipe and Fittings.
j. C606, Grooved and Shouldered Joints.

5. American Welding Society (AWS):
   a. Brazing Handbook.
   b. A5.8M/A5.8, Specification for Filler Metals for Brazing and Braze Welding.
   c. D1.1/D1.1M, Structural Welding Code - Steel.
   d. QC1, Standard for AWS Certification of Welding Inspectors.
6. ASTM International (ASTM):
   a. A47/A47M, Standard Specification for Ferritic Malleable Iron Castings.
   b. A53/A53M, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
   c. A105/A105M, Standard Specification for Carbon Steel Forgings for Piping Applications.
   d. A106/A106M, Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service.
   e. A126, Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
   f. A135/A135M, Standard Specification for Electric-Resistance-Welder Steel Pipe.
   g. A139/A139M, Standard Specification for Electro-Fusion (Arc)–Welded Steel Pipe (NPS 4 Inches and Over).
   h. A153/A153M, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
   i. A181/A181M, Standard Specification for Carbon Steel Forgings, for General-Purpose Piping.
   j. A182/A182M, Standard Specification for Forged or Rolled Alloy and Stainless Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service.
   k. A183, Standard Specification for Carbon Steel Track Bolts and Nuts.
   l. A193/A193M, Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.

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m. A194/A194M, Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
n. A197/A197M, Standard Specification for Cupola Malleable Iron.
o. A216/A216M, Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service.
p. A234/A234M, Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service.
q. A240/A240M, Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications.
r. A276, Standard Specification for Stainless Steel Bars and Shapes.
s. A269, Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service.
t. A307, Standard Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength.
u. A312/A312M, Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes.
v. A320/A320M, Standard Specification for Alloy-Steel and Stainless Steel Bolting for Low-Temperature Service.
w. A351/A351M, Standard Specification for Castings, Austenitic, for Pressure-Containing Parts.
x. A395/A395M, Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures.
y. A403/A403M, Standard Specification for Wrought Austenitic Stainless Steel Piping Fittings.
z. A409/A409M, Standard Specification for Welded Large Diameter Austenitic Steel Pipe for Corrosive or High-Temperature Service.
aa. A536, Standard Specification for Ductile Iron Castings.
bb. A563, Standard Specification for Carbon and Alloy Steel Nuts.
cc. A587, Standard Specification for Electric-Resistance-Welded Low-Carbon Steel Pipe for the Chemical Industry.
dd. A743/A743M, Standard Specification for Castings, Iron-Chromium, Iron-Chromium-Nickel, Corrosion Resistant, for General Application.
ee. A744/A744M, Standard Specification for Castings, Iron-Chromium-Nickel, Corrosion Resistant, for Severe Service.
ff. A774/A774M, Standard Specification for As-Welded Wrought Austenitic Stainless Steel Fittings for General Corrosive Service at Low and Moderate Temperatures.
gg. A778, Standard Specification for Welded, Unannealed Austenitic Stainless Steel Tubular Products.
hh. B32, Standard Specification for Solder Metal.
ii. B43, Standard Specification for Seamless Red Brass Pipe, Standard Sizes.

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jj. B61, Standard Specification for Steam or Valve Bronze Castings.
kk. B62, Standard Specification for Composition Bronze or Ounce Metal Castings.
ll. B75/B75M, Standard Specification for Seamless Copper Tube.
mm. B88, Standard Specification for Seamless Copper Water Tube.
nn. B98/B98M, Standard Specification for Copper-Silicon Alloy Rod, Bar and Shapes.
oo. B462, Standard Specification for Forged or Rolled UNS N06030, UNS N06022, UNS N06035, UNS N06200, UNS N06059, UNS N10362, UNS N06686, UNS N08020, UNS N08024, UNS N08026, UNS N08367, UNS N10276, UNS N10665, UNS N10675, UNS N10629, UNS N08031, UNS N06045, UNS N06025, and UNS R20033 Alloy Pipe Flanges, Forged Fittings, and Valves and Parts for Corrosive High-Temperature Service.
pp. B464, Standard Specification for Welded UNS N08020 Alloy Pipe.
qq. B474, Standard Specification for Electric Fusion Welded Nickel and Nickel Alloy Pipe.
rr. C582, Standard Specification for Contact-Molded Reinforced Thermosetting Plastic (RTP) Laminates for Corrosion-Resistant Equipment.
ss. D412, Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers-Tension.
tt. D413, Standard Test Methods for Rubber Property-Adhesion to Flexible Substrate.
uu. D543, Standard Practices for Evaluating the Resistance of Plastics to Chemical Reagents.
vv. D1248, Standard Specification for Polyethylene Plastics Extrusion Materials for Wire and Cable.
ww. D1330, Standard Specification for Rubber Sheet Gaskets.
xx. D1784, Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.
yy. D1785, Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.
zz. D2000, Standard Classification System for Rubber Products in Automotive Applications.
aaa. D2310, Standard Classification for Machine-Made “Fiberglass” (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe.
bbb. D2464, Standard Specification for Threaded Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.
ccc. D2466, Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.
ddd. D2467, Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80.

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eee. D2564, Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems.
fff. D2837, Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials or Pressure Design Basis for Thermoplastic Pipe Products.
ggg. D2996, Standard Specification for Filament-Wound "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe.
hhh. D3222, Standard Specification for Unmodified Poly(Vinylidene Fluoride) (PVDF) Molding Extrusion and Coating Materials.
iii. D3350, Standard Specification for Polyethylene Plastics Pipe and Fittings Materials.
jjj. D4101, Standard Specification for Polypropylene Injection and Extrusion Materials.
kkk. D4894, Standard Specification for Polytetrafluoroethylene (PTFE) Granular Molding and Ram Extrusion Materials.
lll. D4895, Standard Specification for Polytetrafluoroethylene (PTFE) Resin Produced from Dispersion.
mmm. F423, Standard Specification for Polytetrafluoroethylene (PTFE) Plastic-Lined Ferrous Metal Pipe, Fittings, and Flanges.
nnn. F436, Standard Specification for Hardened Steel Washers.
ooo. F437, Standard Specification for Threaded Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80.
ppp. F439, Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe Fittings, Schedule 80.
qqq. F441/F441M, Standard Specification for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe, Schedules 40 and 80.
rrr. F493, Standard Specification for Solvent Cements for Chlorinated Poly(Vinyl Chloride) (CPVC) Plastic Pipe and Fittings.
sss. F593, Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs.
ttt. F656, Standard Specification for Primers for Use in Solvent Cement Joints of Poly(Vinyl Chloride) (PVC) Plastic Pipe and Fittings.

7. FM Global (FM).
8. Manufacturers Standardization Society of the Valve and Fittings Industry, Inc. (MSS): SP-43, Wrought and Fabricated Butt-Welding Fittings for Low-Pressure, Corrosion Resistant Applications.
9. NSF International (NSF):
   a. ANSI 61: Drinking Water System Components - Health Effects.
   b. ANSI 372: Drinking Water System Components - Lead Content.
10. National Electrical Manufacturers Association (NEMA): LI 1, Industrial Laminating Thermosetting Products.
11. National Fire Protection Association (NFPA): 24, Standard for the Installation of Private Fire Service Mains and Their Appurtenances.

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1.02 DEFINITIONS

A. Submerged or Wetted:

1. Zone below elevation of:
   a. Top face of channel walls and cover slabs.
   b. Liquid surface or within 2 feet above top of liquid surface.
   c. Top of tank wall or under tank cover.

1.03 DESIGN REQUIREMENTS

A. Where pipe diameter, thickness, pressure class, pressure rating, or thrust restraint is not shown or specified, design piping system in accordance with the following:

1. Process Piping: ASME B31.3, normal fluid service unless otherwise specified.
2. Building Service Piping: ASME B31.9, as applicable.
   a. Sanitary Building Drainage and Vent Systems: ICC International Plumbing Code and local plumbing code.
3. Buried Piping: H20-S16 traffic load with 1.5 impact factor, AASHTO HB-17, as applicable.
4. Thrust Restraints:
   a. Design for test pressure shown in Piping Schedule.
   b. Allowable Soil Pressure: 1,000 pounds per square foot.
   c. Low Pressure Pipelines:
      1) When bearing surface of the fitting against soil provides an area equal to or greater than area required for thrust restraint, concrete thrust blocks will not be required.
      2) Determine bearing area for fittings without thrust blocks by projected area of 70 percent of internal diameter multiplied by chord length for fitting centerline curve.

1.04 SUBMITTALS

A. Action Submittals:

1. Shop Fabricated Piping:
   a. Detailed pipe fabrication or spool drawings showing special fittings and bends, dimensions, coatings, and other pertinent information.
   b. Layout drawing showing location of each pipe section and each special length; number or otherwise designate laying sequence on each piece.
2. Pipe Wall Thickness: Identify wall thickness and rational method or standard applied to determine wall thickness for each size of each

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different service including exposed, submerged, buried, and concrete-encased installations for Contractor-designed piping.

3. Hydraulic Thrust Restraint for Restrained Joints: Details including materials, sizes, assembly ratings, and pipe attachment methods.
4. Thrust Blocks: Concrete quantity, bearing area on pipe, and fitting joint locations.
5. Dissimilar Buried Pipe Joints: Joint types and assembly drawings.
6. Pipe Corrosion Protection: Product data.
7. Anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.

B. Informational Submittals:

1. Manufacturer's Certification of Compliance, in accordance with Section 01 61 00, Common Product Requirements:
   a. Pipe and fittings.
   b. Factory applied resins and coatings.
2. Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
3. Flanged Pipe and Fittings: Manufacturer's product data sheets for gaskets including torqueing requirements and bolt tightening procedures.
4. Qualifications:
   a. Nondestructive Testing Personnel: SNT-TC-1A Level II certification and qualifications.
   b. AWS QC1 Certified Welding Inspector: Submit evidence of current certification prior to commencement of welding activities.
   c. Welders:
      1) Continuity log for welders and welding operators.
      2) Welder qualification test records conducted by Contractor or manufacturer.
5. Welding Procedures: Qualified in accordance with ASME Boiler and Pressure Vessel Code, Section IX for weld type(s) and base metal(s).
6. Nondestructive inspection and testing procedures.
7. Test logs.
8. Pipe coating applicator certification.
9. Laboratory Testing Equipment: Certified calibrations, manufacturer's product data, and test procedures.
10. CWI inspection records and NDE test records.
11. Component and attachment testing seismic certificate of compliance as required by Section 01 45 33, Special Inspection, Observation, and Testing.

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1.05 QUALITY ASSURANCE

A. Qualifications:

1. Independent Inspection and Testing Agency:
   a. Ten years' experience in field of welding and welded pipe and fittings' testing required for this Project.
   b. Calibrated instruments and equipment, and documented standard procedures for performing specified testing.
   c. Certified in accordance with ASNT SNT-TC-1A for testing procedures required for this Project.
   d. Testing Agency: Personnel performing tests shall be NDT Level II certified in accordance with ASNT SNT-TC-1A.
   e. Verification Welding Inspector: AWS QC1 Certified.
2. Welding Procedures: In accordance with ASME BPVC SEC IX (Forms QW-482 and QW-483) or AWS D1.1/D1.1M (Annex N Forms).
3. Welder Qualifications: In accordance ASME BPVC SEC IX (Form QW-484) or AWS D1.1/D1.1M (Annex N Forms).
4. Contractor's CWI: Certified in accordance with AWS QC1, and having prior experience with specified welding codes. Alternate welding inspector qualifications require approval by Engineer.
5. Solvent Welder For Double Wall Containment Piping: Qualified in accordance with Chapter VII of the ASME B31.3 Code, Part 9, Paragraph A328.

B. Quality Assurance: **[A: Provide services of] [B: Special inspection to be provided by Owner and performed by]** independent inspection and testing agency for welding operations.

1. Note, the presence of Owner's Special Inspector or Verification CWI does not relieve Contractor from performing own quality control, including 100 percent visual inspection of welds.

1.06 DELIVERY, STORAGE, AND HANDLING

A. In accordance with Section 01 61 00, Common Product Requirements, and:

1. Flanges: Securely attach metal, hardboard, or wood protectors over entire gasket surface.
2. Threaded or Socket Welding Ends: Fit with metal, wood, or plastic plugs or caps.
3. Linings and Coatings: Prevent excessive drying.
4. Cold Weather Storage: Locate products to prevent coating from freezing to ground.
5. Handling: Use heavy canvas or nylon slings to lift pipe and fittings.

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PART 2 PRODUCTS

2.01 GENERAL

A. Components and Materials in Contact with Water for Human Consumption: Comply with the requirements of the Safe Drinking Water Act and other applicable federal, state, and local requirements. Provide certification by manufacturer or an accredited certification organization recognized by the Authority Having Jurisdiction that components and materials comply with the maximum lead content standard in accordance with NSF/ANSI 61 and NSF/ANSI 372.

1. Use or reuse of components and materials without a traceable certification is prohibited.

2.02 PIPING

A. As specified on Piping Data Sheet(s) and Piping Schedule located on Drawings.

B. Diameters Shown:

1. Standardized Products: Nominal size.
2. Fabricated Steel Piping (Except Cement-Lined): Outside diameter, ASME B36.10M.
3. Cement-Lined Steel Pipe: Lining inside diameter.

2.03 JOINTS

A. Flanged Joints:

1. Flat-faced, carbon steel, or alloy flanges when mating with flat-faced cast or ductile iron flanges.
2. Higher pressure rated flanges as required to mate with equipment when equipment flange is of higher pressure rating than required for piping.

B. Threaded Joints: NPT taper pipe threads in accordance with ASME B1.20.1.

C. Mechanical Joint Anchor Gland Follower:

1. Ductile iron anchor type, wedge action, with break-off tightening bolts.
2. Thrust rated to 250 psi minimum.
3. Rated operating deflection not less than:
   a. 3 degrees for sizes through 12 inches.
   b. 2 degrees for sizes 14 inches through 16 inches.

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c. 1.5 degrees for sizes 18 inches through 24 inches.
d. 1 degree for sizes 30 inches through 48 inches.

4. UL and FM approved.

D. Flexible Mechanical Compression Joint Coupling:

1. Stainless steel, ASTM A276, Type 305 bands.
2. Manufacturers:
   a. Pipeline Products Corp.
   b. Fernco Joint Sealer Co.

E. Mechanical connections of high-density polyethylene pipe to auxiliary equipment such as valves, pumps, tanks, and other piping systems shall be through-flanged connections consisting of the following:

1. Polyethylene stub end thermally butt-fused to end of pipe.
2. ASTM A240/A240M, Type 304 stainless steel backing flange, 125-pound, ASME B16.1 standard. Use insulating flanges where shown.
3. Bolts and nuts of sufficient length to show a minimum of three complete threads when joint is made and tightened to manufacturer's standard. Retorque nuts after 4 hours.
4. Gaskets as specified on Data Sheet.

2.04 GASKET LUBRICANT

A. Lubricant shall be supplied by pipe manufacturer and no substitute or "or-equal" will be allowed.

2.05 DOUBLE-CONTAINED PIPING SYSTEM

A. Definitions:

1. Carrier Pipe or Tube and Fittings: Shall refer to the inner or primary piping (or tubing) continuously subjected to liquids or vapors.
2. Containment Pipe and Fittings: Shall refer to the outer pipe or secondary pipe subject to liquids or vapors only on leakage from the carrier pipe.
3. Centralizers: Shall refer to clip device to keep carrier pipe located in the center of containment conduit.

B. Double-contained piping systems shall include two variations of secondary containment:

1. Secondary containment includes:
   a. Carrier pipe or tube, valves, and fittings.
   b. Containment pipe and fittings.

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c. Low point containment boxes with drain valve and leak detection, as required.
d. Valve containment boxes with drain valve and leak detection, as required.
e. Piping runs sloped to containment boxes.

2. If potential quantity of accumulated chemical from a leak in the double-containment pipe exceeds 50 gallons, leak detection at a local low point is required. The leak detection with alarm shall be connected into the SCADA System. Otherwise, the leak detection tee shall be plugged with a threaded plug.

C. Secondary containment shall be provided for services and at locations identified in the Drawings and on pipe schedule.

D. Containment pipe and fittings will begin and terminate a minimum of 2 feet inside chemical containment areas or as identified on Drawings.

E. Minimum size for outer containment piping shall be as stated below. This information is for reference. Installation capability is determined by distance of tubing pull and number of bends.

Carrier Pipe/Tube(s) Nominal Diameter	**Minimum Containment Pipe, Nominal Diameter, inches**
One 1/4-inch tube	1
One 3/8-inch tube	1
One 1/2-inch tube	2
One 3/4-inch tube	2
One 1-inch tube	2
One 1-1/4-inch tube	2
One 1-1/2-inch tube	4
Two 1/4-inch tubes	2
Two 3/8-inch tubes	4
Two 1/2-inch tubes	4
Two 3/4-inch tubes	4
Two 1-inch tubes	4
Two 1-1/4-inch tubes	4
Note: For other combinations and sizes, do not exceed 25 percent fill area of containment piping.	

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F. Provide valve containment, where identified on drawings, by joining the containment piping to a valve containment box constructed of PVC. The box shall extend a minimum of 4 inches beyond the valve in all directions. A drain valve shall be provided on the bottom of each box.

G. Secondary Containment Boxes:

1. Secondary containment boxes shall be provided at locations identified on the Drawings.
2. Leak detection shall be supplied and installed as shown on the Drawings and in accordance with the requirements of Section.

H. Low-point containment drain valves shall be in accordance with the pipe class specification sheets included at the end of this Section.

I. Provide pipe supports in accordance with Section 40 05 15, Pipe Support Systems.

J. Containment piping shall be labeled to match carrier piping flow stream labels as identified in Pipe Schedule and in accordance with Section 10 14 00 Signage.

2.06 PIPE CORROSION PROTECTION

A. Coatings: See Section 09 90 00, Painting and Coating, for details of coating requirements.

B. Insulating Flanges, Couplings, and Unions:

1. Materials:
   a. In accordance with applicable piping material specified in Pipe Data Sheet. Complete assembly shall have ASME B31.3 or B31.9 working pressure rating equal to or higher than that of joint and pipeline.
   b. Galvanically compatible with piping.
   c. Resistant for intended exposure, operating temperatures, and products in pipeline.
2. Union Type, 2 Inches and Smaller:
   a. Screwed or solder-joint.
   b. O-ring sealed with molded and bonded insulation to body.
3. Flange Type, 2-1/2 Inches and Larger:
   a. Flanged, complete with bolt insulators, dielectric gasket, bolts, and nuts.
   b. Bolt insulating sleeves shall be provided full length between insulating washers.
   c. Ensure fit-up of components of insulated flange assembly to provide a complete functioning installation.

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d. AWWA C207 steel flanges may be drilled oversize up to 1/8-inch to accommodate insulating sleeves.
e. No less than minimum thread engagement in accordance with specified bolting standards will be permitted to accommodate thicknesses of required washers, flanges, and gasket.

4. Flange Insulating Kits:[NB1]
   a. Gaskets: Full-face, Type E with elastomeric sealing element. Sealing element shall be retained in a groove within retainer portion of gasket.
   b. Insulating Sleeves: Full-length fiberglass reinforced epoxy (G-10 grade).
   c. Insulating Washers: Fiberglass-reinforced epoxy (G-10 grade).
   d. Steel Washers: Plated, hot-rolled steel or Hardened steel, ASTM F436**,** 1/8 inch thick.
      1) Flange Diameters 36 Inches or Less: Provide two washers per bolt.
      2) Flange Diameters Larger Than 36 Inches: Provide four washers per bolt.

5. Manufacturers and Products:[VC2]
   a. Dielectric Flanges and Unions:
      1) PSI, Houston, TX.
      2) Advance Products and Systems, Lafayette, LA.
   b. Insulating Couplings:
      1) Dresser; **[J: STAB-39] [K:].**
      2) Baker Coupling Company, Inc.; **[L: Series 216] [M:].**

2.07 THRUST BLOCKS

A. Concrete: As specified in Section 03 30 00, Cast-in-Place Concrete.

2.08 THRUST TIES

A. Steel Pipe: Joint harness as specified in Section 40 27 01, Process Piping Specialties.

B. Buried Ductile Iron Pipe and Fittings: Unless restraint is otherwise specified or shown, conform to NFPA 24. Tie-rod attachments relying on clamp friction with pipe barrel to restrain thrust are unacceptable.

2.09 VENT AND DRAIN VALVES

A. Pipeline 2-Inch Diameter and Smaller: 1/2-inch vent, 1-inch drain, unless shown otherwise.

B. Pipelines 2-1/2-Inch Diameter and Larger: 3/4-inch vent, 1-inch drain, unless shown otherwise.

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2.10 FABRICATION

A. Mark each pipe length on outside with the following:

1. Size or diameter and class.
2. Manufacturer’s identification and pipe serial number.
3. Location number on laying drawing.
4. Date of manufacture.

B. Code markings according to approved Shop Drawings.

C. Shop fabricate flanged pipe in shop, not in field, and delivered to Site with flanges in place and properly faced. Threaded flanges shall be individually fitted and machine tightened on matching threaded pipe by manufacturer.

2.11 FINISHES

A. Factory prepare, prime, and finish coat in accordance with Pipe Data Sheet(s) and Piping Schedule.

B. Galvanizing:

1. Hot-dip applied, meeting requirements of ASTM A153/A153M.
2. Electroplated zinc or cadmium plating is unacceptable.
3. Stainless steel components may be substituted where galvanizing is specified.

PART 3 EXECUTION

3.01 EXAMINATION

A. Verify size, material, joint types, elevation, horizontal location, and pipe service of existing pipelines to be connected to new pipelines or new equipment.

B. Inspect size and location of structure penetrations to verify adequacy of wall pipes, sleeves, and other openings.

3.02 PREPARATION

A. See Piping Schedule and Section 09 90 00, Painting and Coating, for additional requirements.

B. Notify Engineer at least 2 weeks prior to field fabrication of pipe or fittings.

C. Inspect pipe and fittings before installation, clean ends thoroughly, and remove foreign matter and dirt from inside.

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D. Damaged Coatings and Linings: Repair using original coating and lining materials in accordance with manufacturer's instructions, except for damaged glass-lined pipe or PVDF-lined pipe that is to be promptly removed from Site.

3.03 WELDING

A. Perform in accordance with Section IX, ASME Boiler and Pressure Vessel Code and ASME B31.3 for Pressure Piping, as may be specified on Piping Data Sheets, and if recommended by piping or fitting manufacturer.

B. Weld Identification: Keep paper record of which welder welded each joint.

C. Pipe End Preparation:

1. Machine Shaping: Preferred.
2. Oxygen or Arc Cutting: Smooth to touch, true, and slag removal by chipping or grinding.
3. Beveled Ends for Butt Welding: ASME B16.25.

D. Surfaces:

1. Clean and free of paint, oil, rust, scale, slag, or other material detrimental to welding.
2. Clean stainless steel joints with stainless steel wire brushes or stainless steel wool prior to welding.
3. Thoroughly clean each layer of deposited weld metal, including final pass, prior to deposition of each additional layer of weld metal with a power-driven wire brush.

E. Alignment and Spacing:

1. Align ends to be joined within existing commercial tolerances on diameters, wall thicknesses, and out-of-roundness.
2. Root Opening of Joint: As stated in qualified welding procedure.
3. Minimum Spacing of Circumferential Butt Welds: Minimum four times pipe wall thickness or 1 inch, whichever is greater.

F. Climatic Conditions:

1. Do not perform welding if there is impingement of any rain, snow, sleet, or wind exceeding 5 mph on the weld area, or if ambient temperature is below 32 degrees F.
2. Stainless Steel and Alloy Piping: If ambient is less than 32 degrees F, local preheating to a temperature warm to the hand is required.

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G. Tack Welds: Performed by qualified welder using same procedure as for completed weld, made with electrode similar or equivalent to electrode to be used for first weld pass, and not defective. Remove those not meeting requirements prior to commencing welding procedures.

H. Surface Defects: Chip or grind out those affecting soundness of weld.

I. Weld Quality: Meet requirements of governing welding codes.

3.04 INSTALLATION—GENERAL

A. Join pipe and fittings in accordance with manufacturer's instructions, unless otherwise shown or specified.

B. Remove foreign objects prior to assembly and installation.

C. Pulled Tubing Through Containment Piping.

1. Limit a pull to no more than 270 degrees of combine changes in direction or 500 feet of pipe length, whichever is greater, between pull boxes.
2. Use pull tape, NOT rope or wire, to avoid damaging containment pipe.
3. Do not use fittings that will kink or induce point forces on the carrier piping during pulling. Use long radius bends and heat bends as identified in drawings.
4. Limit pull force to prevent permanent tubing deformation, verify maximum pull force with tubing manufacturer.
5. Limit pull speed to prevent damage to tubing, verify maximum pull speed with tubing manufacturer.
6. Lubricant:
    a. Apply generous amounts of lubricant on the outside of the carrier tube during pulling, to reduce friction and prevent damage to the carrier pipe or containment pipe due to friction.
    b. Lubricant must be chemically compatible with carrier tube and containment pipe.
    c. Lubricant type to be submitted for approval by engineer.

D. Non-Metallic Piping and Tubing:

1. Qualify bonders for each bonding procedure specification (BPS) for each piping service in conformance with ASME B31.3 Chapter VII A328 BONDING OF PLASTICS.
2. In addition to the above requirements, welders for PFA, PP, and PVDF pipe must meet the following additional criteria:
    a. Certified by the piping manufacturer in each fusion process within the past 2 years. Display certificate of qualification at all times.

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b. Qualified for this project (at the Contractor's expense) by being trained in project protocol and the requirements of this Specification and by making at least three typical pipe joints in a test spool piece that withstands a test pressure of 1.5 times the design pressure. Include one flanged joint in the spool. Testing to be witnessed by the Examiner and Inspector.
c. Provide a sample of correctly welded pipe and fittings in the work area to serve as a reference check of welds.
d. Each fitter must submit a sample fused joint to the Examiner for inspection at the following times:
    1) Indication of defective weld.
    2) Change in weld area temperature of 20 degrees F.
    3) As directed by the Examiner.

E. Flanged Joints:

1. Install perpendicular to pipe centerline.
2. Bolt Holes: Straddle vertical centerlines, aligned with connecting equipment flanges or as shown.
3. Use torque-limiting wrenches to ensure uniform bearing and proper bolt tightness.
4. Plastic Flanges: Install annular ring filler gasket at joints of raised-face flange.
5. Grooved Joint Flange Adapters: Include stainless steel washer plates as required for mating to serrated faces and lined valves and equipment.
6. Raised-Face Flanges: Use flat-face flange when joining with flat-faced ductile or cast iron flange.
7. Verify compatibility of mating flange to adapter flange gasket prior to selecting grooved adapter flanging.
8. Flange fillers are to be avoided, but if necessary, may be used to make up for small angles up to 6 degrees and for filling gaps up to 2 inches between flanges. Stacked flange fillers shall not be used.
9. Threaded flanged joints shall be shop fabricated and delivered to Site with flanges in-place and properly faced.
10. Manufacturer: Same as pipe manufacturer.

F. Threaded and Coupled Joints:

1. Conform to ASME B1.20.1.
2. Produce sufficient thread length to ensure full engagement when screwed home in fittings.
3. Countersink pipe ends, ream and clean chips and burrs after threading.
4. Make connections with not more than three threads exposed.
5. Lubricate male threads only with thread lubricant or tape as specified on Piping Data Sheets.

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G. Grooved-End Joints:

1. Piping shall be grooved in accordance with manufacturer's latest published instructions and shall be accurately cut with tools conforming to coupling manufacturer's standards and to AWWA C606.
2. Install grooved joint couplings and gaskets in accordance with manufacturer's latest published installation instructions.

H. Soldered Joints:

1. Use only solder specified for particular service.
2. Cut pipe ends square and remove fins and burrs.
3. After thoroughly cleaning pipe and fitting of oil and grease using solvent and emery cloth, apply noncorrosive flux to the male end only.
4. Wipe excess solder from exterior of joint before hardened.
5. Before soldering, remove stems and washers from solder joint valves.

I. Brazed Joints for Refrigerant Piping:

1. Braze copper piping with silver solder complying with AWS A5.8/A5.8M.
2. Construct joints according to AWS Brazing Handbook, Chapter Pipe and Tube.
3. Inside of tubing and fittings shall be free of flux.
4. Clean parts to be joined with emery cloth and keep hot until solder has penetrated the full depth of the fitting and extra flux has been expelled.
5. Cool joints in air and remove flame marks and traces of flux.
6. During brazing operation, prevent an oxide film from forming on inside of tubing by slowly flowing dry nitrogen to expel the air.
7. When brazing, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion valve bulb.

J. Pipe Connections at Concrete Structures: As specified in Article Piping Flexibility Provisions in Section 40 27 01, Process Piping Specialties.

K. PVC and CPVC Piping:

1. Provide Schedule 80 threaded nipple where necessary to connect to threaded valve or fitting.
2. Use strap wrench for tightening threaded plastic joints. Do not overtighten fittings.
3. Do not thread Schedule 40 pipe.

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L. PFA TUBING:

1. Fabricate and install in conformance with approved bonding procedure specification (BPS) and the following:
    a. BPS to be based on piping system and bonding equipment manufacturer's recommended procedures.
    b. Use cutting and fusion tools and equipment only as recommended by the manufacturer. Operate tools and equipment per the manufacturer's instructions.
    c. Make thermal fusion welds by heating the appropriate connections only once. Repair practices such as back-welding that reheat pipe connections are unacceptable. Hot air and rod-welding is unacceptable. Cut-out and replace connections that are faulty or improperly welded at no additional cost to the Owner.
    d. Welds made with hand-held heating devices are not allowed. Use flanges and unions where necessary, in lieu of hand welds.
    e. Protect small projections from the piping system, such as sample ports, vents, and drains, to avoid breakage.

M. Ductile Iron Piping:

1. Cutting Pipe: Cut pipe with milling type cutter, rolling pipe cutter, or abrasive blade cutter. Do not flame cut.
2. Dressing Cut Ends:
    a. General: As required for the type of joint to be made.
    b. Rubber Gasketed Joints: Remove sharp edges or projections.
    c. Push-On Joints: Bevel, as recommended by pipe manufacturer.
    d. Flexible Couplings, Flanged Coupling Adapters, and Grooved End Pipe Couplings: As recommended by the coupling or adapter manufacturer.

N. High-Density Polyethylene Piping:

1. Join pipes, fittings, and flange connections by means of thermal butt-fusion.
2. Perform butt-fusion in accordance with pipe manufacturer's recommendations as to equipment and technique.
3. Special Precautions at Flanges: Polyethylene pipe connected to heavy fittings, manholes, and rigid structures shall be supported in such a manner that no subsequent relative movement between polyethylene pipe at flanged joint and rigid structures is possible.

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3.05 INSTALLATION—EXPOSED PIPING

A. Piping Runs:

1. Parallel to building or column lines and perpendicular to floor, unless shown otherwise.
2. Piping upstream and downstream of flow measuring devices shall provide straight lengths as required for accurate flow measurement.

B. Supports: As specified in Section 40 05 15, Piping Support Systems.

C. Group piping wherever practical at common elevations; install to conserve building space and not interfere with use of space and other work.

D. Unions or Flanges: Provide at each piping connection to equipment or instrumentation on equipment side of each block valve to facilitate installation and removal.

E. Install piping so that no load or movement in excess of that stipulated by equipment manufacturer will be imposed upon equipment connection; install to allow for contraction and expansion without stressing pipe, joints, or connected equipment.

F. Piping clearance, unless otherwise shown:

1. Over Walkway and Stairs: Minimum of 7 feet 6 inches, measured from walking surface or stair tread to lowest extremity of piping system including flanges, valve bodies or mechanisms, insulation, or hanger/support systems.
2. Between Equipment or Equipment Piping and Adjacent Piping: Minimum 3 feet, measured from equipment extremity and extremity of piping system including flanges, valve bodies or mechanisms, insulation, or hanger/support systems.
3. From Adjacent Work: Minimum 1 inch from nearest extremity of completed piping system including flanges, valve bodies or mechanisms, insulation, or hanger/support systems.
4. Do not route piping in front of or to interfere with access ways, ladders, stairs, platforms, walkways, openings, doors, or windows.
5. Headroom in front of openings, doors, and windows shall not be less than the top of the opening.
6. Do not install piping containing liquids or liquid vapors in transformer vaults or electrical equipment rooms.
7. Do not route piping over, around, in front of, in back of, or below electrical equipment including controls, panels, switches, terminals, boxes, or other similar electrical work.

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3.06 INSTALLATION—BURIED PIPE

A. Joints:

1. Dissimilar Buried Pipes:
   a. Provide flexible mechanical compression joints for pressure pipe.
   b. Provide concrete closure collar for gravity and low pressure (maximum 10 psi) piping or as shown.
2. Concrete Encased or Embedded Pipe: Do not encase joints in concrete, unless specifically shown.

B. Placement:

1. Keep trench dry until pipe laying and joining are completed.
2. Pipe Base and Pipe Zone: As specified in Section 31 23 23.15, Trench Backfill.
3. Exercise care when lowering pipe into trench to prevent twisting or damage to pipe.
4. Measure for grade at pipe invert, not at top of pipe.
5. Excavate trench bottom and sides of ample dimensions to permit visual inspection and testing of entire flange, valve, or connection.
6. Prevent foreign material from entering pipe during placement.
7. Close and block open end of last laid pipe section when placement operations are not in progress and at close of day's work.
8. Lay pipe upgrade with bell ends pointing in direction of laying.
9. Install closure sections and adapters for gravity piping at locations where pipe laying changes direction.
10. Deflect pipe at joints for pipelines laid on a curve using unsymmetrical closure of spigot into bell. If joint deflection of standard pipe lengths will not accommodate horizontal or vertical curves in alignment, provide:
    a. Shorter pipe lengths.
    b. Special mitered joints.
    c. Standard or special fabricated bends.
11. After joint has been made, check pipe alignment and grade.
12. Place sufficient pipe zone material to secure pipe from movement before next joint is installed.
13. Prevent uplift and floating of pipe prior to backfilling.

C. PVC, CPVC, or HDPE Pipe Placement:

1. Lay pipe snaking from one side of trench to other.
2. Offset: As recommended by manufacturer for maximum temperature variation between time of solvent welding and during operation.

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3. Do not lay pipe when temperature is below 40 degrees F, or above 90 degrees F when exposed to direct sunlight.
4. Shield ends to be joined from direct sunlight prior to and during the laying operation.

D. Tolerances:

1. Deflection from Horizontal Line, Except PVC, CPVC, or HDPE: Maximum 2 inches.
2. Deflection From Vertical Grade: Maximum 1/4 inch.
3. Joint Deflection: Maximum of 75 percent of manufacturer's recommendation.
4. Horizontal position of pipe centerline on alignment around curves maximum variation of 1.75 feet from position shown.
5. Pipe Cover: Minimum 3 feet, unless otherwise shown.

3.07 INSTALLATION—CONCRETE ENCASED

A. Provide reinforced concrete pipe encasement where shown on Drawings and where otherwise required. Some piping may be required to be concrete encased for pipe strength requirements that are included in the Specifications. Piping under and within the influence of buildings, utility trenches, vaults, slabs, and other structures shall be concrete encased. See details on Drawings for encasement requirements.

B. Where concrete encased piping crosses structure construction and expansion joints, provide flexible piping joints to coincide with structure joints to prevent excessive pipe stress and breakage.

3.08 INSTALLATION—DOUBLE WALL CONTAINMENT PIPING SYSTEM

A. Install according to manufacturer's instructions.

B. Valves and equipment shall be supported independently from pipe. Anchor valves such that turning moment resulting from their operation will not be transmitted to pipe.

C. Following Installation and Testing:

1. Flush clean carrier and containment piping system.
2. Purge annular space of moisture with clean, dry air.

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3.09 LEAK DETECTION SYSTEM FOR DOUBLE WALL CONTAINMENT PIPING[NB3]

A. Install spot detectors in containment piping system at low point drains and where identified on drawings, in accordance with leak detection system manufacturer's instructions and recommendations.

3.10 PIPE CORROSION PROTECTION

A. Ductile Iron Pipe:

1. Exposed: As specified in Section 09 90 00, Painting and Coating, and as shown in Piping Schedule.
2. Buried: Pipe manufacturers zinc coating with bitumastic overcoat at 1 mil minimum dry film thickness.
3. Submerged or Embedded: Coat with epoxy as specified in Section 09 90 00, Painting and Coating. If in potable water service, use NSF/ANSI 61 approved epoxy.

B. Carbon Steel Pipe:

1. Exposed: As specified in Section 09 90 00, Painting and Coating.
2. Buried:
   a. Pipe: Fusion bonded epoxy coating system as specified in Section 09 90 00, Painting and Coating.
   b. Joints: heat shrink wrap as specified herein.
3. Submerged or Embedded: Shop coat with coal-tar epoxy as specified in Section 09 90 00, Painting and Coating. If in potable water service, use NSF/ANSI 61 approved epoxy.

C. Copper Pipe:

1. Exposed: As specified in Section 09 90 00, Painting and Coating.
2. Buried: Tape wrap in accordance with Section 09 90 00, Painting and Coating.

D. PVC and CPVC Pipe, Exposed: As specified in Section 09 90 00, Painting and Coating.

E. Piping Accessories and Specialties:

1. Piping accessories and specialties listed below and as identified in Section 40 27 01, Process Piping Specialties.
2. Exposed:
   a. Field paint black and galvanized steel, brass, copper, and bronze piping components as specified in Section 09 90 00, Painting and Coating, as applicable to base metal material.

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b. Accessories include, but are not limited to, pipe hangers, supports, expansion joints, pipe guides, flexible couplings, vent and drain valves, and fasteners.

3. Buried:
   a. Ferrous Metal and Stainless Steel Components: Coat with epoxy as specified in Section 09 90 00, Painting and Coating.
   b. Bolts, Nuts, and Similar Items: Coat with bituminous paint.
   c. Valves, Flanged Joints, Restrained Joints, Flexible Couplings and Similar Items: Tape wrap as specified in Section 09 90 00, Painting and Coating.[VC4]

F. Polyethylene Encasement: Not allowed.

G. Tape Coating System: As specified in Section 09 90 00, Painting and Coating.

H. Heat Shrink Wrap: Apply in accordance with AWWA C216 and manufacturer's instructions to surfaces that are cleaned, prepared, and primed.

I. Insulating Flanges, Couplings, and Unions:

1. Applications:
   a. Dissimilar metal piping connections.
   b. Cathodically protected piping penetration to buildings and watertight structures.
   c. Submerged to unsubmerged metallic piping connections.
   d. Where required for electrically insulated connection.
2. Pipe Installation:
   a. Insulating joints connecting immersed piping to nonimmersed piping shall be installed above maximum water surface elevation.
   b. Submerged carbon steel, ductile iron, or galvanized piping in reinforced concrete shall be isolated from the concrete reinforcement steel.
   c. Align and install insulating joints as shown on the Drawings and according to manufacturer's recommendations. Bolt lubricants that contain graphite or other metallic or electrically conductive components that can interfere with the insulating capabilities of the completed flange shall not be used.

J. Pipe Bonding for Buried Piping: As specified in Section 26 42 01, Pipe Bonding and Test Stations.

K. Cathodic Protection for Buried Piping: As specified in Section 26 42 02, Cathodic Protection, and as shown.

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3.11 THRUST RESTRAINT

A. Location:

1. Buried Piping: Where shown and where required to restrain force developed at pipeline tees, plugs, caps, bends, and other locations where unbalanced forces exist because of hydrostatic testing and normal operating pressure.
2. Exposed Piping: At all joints in piping.

B. Thrust Ties:

1. Steel Pipe: Attach with joint harness specified in Section 40 27 01, Process Piping Specialties.
2. Ductile Iron Pipe: Attach with socket clamps anchored against grooved joint coupling or flange.
3. Flanged Coupling Adapters: For exposed installations, install manufacturer's anchor studs through coupling sleeve or use dismantling joints.

C. Mechanical Joint Valve Restraint in Proprietary Restrained Joint Piping: Install pipe joint manufacturer's adapter gland follower and pipe end retainer, or mechanical joint anchor gland follower.

D. Thrust Blocking:

1. Place between undisturbed ground and fitting to be anchored.
2. Quantity of Concrete: Sufficient to cover bearing area on pipe and provide required soil bearing area as shown.
3. Place blocking so that pipe and fitting joints will be accessible for repairs.
4. Place concrete in accordance with Section 03 30 00, Cast-in-Place Concrete.

3.12 SLAB, FLOOR, WALL, AND ROOF PENETRATIONS

A. Application and Installation: As specified in Section 40 27 01, Process Piping Specialties.

3.13 BRANCH CONNECTIONS

A. Do not install branch connections smaller than 1/2-inch nominal pipe size, including instrument connections, unless shown otherwise.

B. When line of lower pressure connects to a line of higher pressure, requirements of Piping Data Sheet for higher pressure rating prevails up to

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and including first block valve in the line carrying the lower pressure, unless otherwise shown.

C. Threaded Pipe Tap Connections:

1. Ductile Iron Piping: Connect only with service saddle or at tapping boss of a fitting, valve body, or equipment casting.
2. Welded Steel or Alloy Piping: Connect only with welded threadolet or half-coupling as specified on Piping Data Sheet.

3.14 VENTS AND DRAINS

A. Vents and drains at high and low points in piping required for completed system may or may not be shown. Install vents on high points and drains on low points of pipelines at all low and high point locations.

3.15 INSULATION

A. See Section 40 42 13, Process Piping Insulation.

3.16 HEAT TRACING

A. See Section 40 05 33, Pipe Heat Tracing.

3.17 DISINFECTION

A. See Section 33 13 00, Disinfecting of Water Utility Distribution.

3.18 FIELD FINISHING

A. Notify Engineer at least 3 days prior to start of surface preparation or coating application work.

B. As specified in Section **[A: 09 90 00, Painting and Coating] [B: 09 90 04, Painting (Short Form)].[NB5]**

3.19 PIPE IDENTIFICATION

A. As specified in Section **[A: 10 14 00, Signage] [B: 31 23 23.15, Trench Backfill] [C: 09 90 00, Painting and Coating] [D: 09 90 04, Painting (Short Form)].[NB6]**

3.20 FIELD QUALITY CONTROL

A. Pressure Leakage Testing: As specified in Section 40 80 01, Process Piping Leakage Testing.

B. Minimum Duties of Welding Inspector:

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1. Job material verification and storage.
2. Qualification of welders.
3. Certify conformance with approved welding procedures.
4. Maintenance of records and preparation of reports in a timely manner.
5. Notification to Engineer of unsatisfactory weld performance within 24 hours of weld test failure.

C. Required Weld Examinations:

1. Perform examinations in accordance with Piping Code, ASME B31.3 for Normal Fluid Service.
2. Perform examinations for every pipe thickness and for each welding procedure, progressively, for piping covered by this section.
3. Examine at least one of each type and position of weld made by each welder or welding operator.
4. For each weld found to be defective under the acceptance standards or limitations on imperfections contained in the applicable Piping Code, examine two additional welds made by the same welder that produced the defective weld. Such additional examinations are in addition to the minimum required above. Examine, progressively, two additional welds for each tracer examination found to be unsatisfactory.

D. Test containment piping leak detection system in accordance with system manufacturer's instructions and recommendations to verify proper operation.

3.21 MANUFACTURER'S SERVICES

A. Provide manufacturer's representative at Site in accordance with Section 01 43 33, Manufacturers' Field Services, to assist with unloading of the double wall containment piping system, system tests, containment pipe joint closure, installation and testing of leak detection system, and training of **[C: Owner's] [D:]** personnel in operation and maintenance of leak detection system. Manufacturer's representative shall complete a Manufacturer's Certificate of Proper Installation. Inspection and examination practices shall be according to ASME B31.3 for Normal Fluid Service.

3.22 CLEANING

A. Following assembly and testing, and prior to disinfection and final acceptance, flush pipelines, except as stated below, with water at 2.5 fps minimum flushing velocity until foreign matter is removed.

B. Blow clean of loose debris plant process air, and instrument air lines with compressed air at 4,000 fpm; do not flush with water.

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C. Immediately after cleaning service piping, dry to minus 40 degrees F dew point with dry compressed instrument air or compressed commercial grade nitrogen.

D. If impractical to flush large diameter pipe at 2.5 fps or blow at 4,000 fpm velocity, clean in-place from inside by brushing and sweeping, then flush or blow line at lower velocity.

E. Insert cone strainers in flushing connections to attached equipment and leave in-place until cleaning is complete.

F. Remove accumulated debris through drains 2 inches and larger or by removing spools and valves from piping.

3.23 SUPPLEMENTS

A. The supplements listed below, following "End of Section," are a part of this Specification:

1. Piping Schedule.
2. Data Sheets.

Number	Title
40 27 00.01	Cement-Mortar-Lined Ductile Iron Pipe and Fittings
40 27 00.03	Carbon Steel Pipe and Fittings—General Service
40 27 00.05	Glass-Lined Carbon Steel Pipe and Fittings
40 27 00.08	Stainless Steel Pipe and Fittings—General Service
40 27 00.10	Polyvinyl Chloride (PVC) Pipe and Fittings
40 27 00.13	Copper and Copper Alloy Pipe, Tubing, and Fittings
40 27 00.18	Polyvinylidene Fluoride (PVDF) Pipe and Fittings
40 27 00.22	Perfluoroalkoxy (PFA) Tubing, Fittings and Secondary Containment

END OF SECTION

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		PIPE SCHEDULE										
FACILITY #	LINE DESCRIPTION	SERVICE	FLOW STREAM IDENTIFICATION	SIZE, INCHES	EXPOSURE	PIPING MATERIAL	PIPE SPEC SECTION	PIPE COATING COLOR (09_90_00)	PIPE LABELING FIELD COLOR (10 14 00)	PIPE LABELING TEXT COLOR (10 14 00)	LABEL TEXT (10 14 00)	NOTES
280	DOWNSTREAM OF FLOC BASINS	CLARIFIED WATER	CLW	>3"	EN, EXI, EXE, S	CLDI	40_27_00.01	AQUA	AQUA	BLACK	CLW, CLARIFIED WATER	
280	DOWNSTREAM OF FLOC BASINS - YARD PIPE	CLARIFIED WATER	CLW	>3"	B	CLDI	40_27_00.01	AQUA	AQUA	BLACK	CLW, CLARIFIED WATER	
280	RAPID MIX FC FEED	FERRIC CHLORIDE, 40%	FC	ALL	B, EXE	PFA (TUBING)	40_27_00.22	--	ORANGE	BLACK	FC, FERRIC CHLORIDE	
280	DRAIN SYSTEM - YARD PIPE	DRAIN (PROCESS)	PD	ALL	B	PVC, C900 DR 32.5	33 05 01.09B	--	GREEN	WHITE	PD, PROCESS DRAIN	
280	RECYCLE FROM FW PS	RECYCLE	RCY	>3"	EN, EXI, EXE, S	CLDI	40_27_00.01	LIGHT GRAY	BLUE	WHITE	RCY, RECYCLED WATER	
280	RECYCLE FROM FWPS - YARD PIPE	RECYCLE	RCY	14"	B	PVC, C905 DR 25	33 05 01.09B	--	BLUE	WHITE	RCY, RECYCLED WATER	
280	RECYCLE FROM DECANT WATER PS - YARD PIPE	RECYCLE	RCY	6"	B	PVC, C900 DR 25	33 05 01.09B	--	BLUE	WHITE	RCY, RECYCLED WATER	
280	RAPID MIX INFLUENT PIPING	RAW WATER	RW	>3"	EN, EXI, EXE, S	CLDI	40_27_00.01	OLIVE GREEN	OLIVE GREEN	WHITE	RW, RAW WATER	
280	RAW WATER FROM TANK 2 - YARD PIPE	RAW WATER	RW	24"	B	PVC, C905 DR 25	33 05 01.09B	--	OLIVE GREEN	WHITE	RW, RAW WATER	
280	RAPID MIX SFA FEED	SULFURIC ACID, 93%	SFA	ALL	B, EXE	PFA (TUBING)	40_27_00.22	--	YELLOW	BLACK	SU, SULFURIC ACID	
280	SLUDGE COLLECTOR DISCHARGE PIPING	UNTHICKENED SLUDGE	USL	>3"	EN, EXI, EXE, S	CLDI	40_27_00.01	DARK BROWN	GREEN	WHITE	USL, UNTHICKENED SLUDGE	
280	UNTHICKENED SLUDGE - YARD PIPE	UNTHICKENED SLUDGE	USL	8"	B	PVC, C900 DR 32.5	33 05 01.09B	--	GREEN	WHITE	USL, UNTHICKENED SLUDGE	
300	FILTER BACKWASH AIR SCOUR SUPPLY	BACKWASH AIR	BWA	ALL	EXI	316 SS, SCH 5S	40_27_00.08	--	BLUE	WHITE	BWA, BACKWASH AIR	INSULATION FOR PERSONNEL PROTECTION ONLY.
300	BACKWASH SUPPLY PIPING - YARD PIPE	BACKWASH SUPPLY	BWS	14"	B	PVC, C905 DR 25	33 05 01.09B	--	BLUE	WHITE	BWS, BACKWASH SUPPLY	
300	BACKWASH SUPPLY PIPING	BACKWASH SUPPLY	BWS	>3"	EN, EXI, EXE, S	CLDI	40_27_00.01	BLUE	BLUE	WHITE	BWS, BACKWASH SUPPLY	
300	GAC BACKWASH WASTE/FTW - YARD PIPE	BACKWASH WASTE	BWW	8"	B	PVC, C900 DR 32.5	33 05 01.09B	--	LIGHT BROWN	WHITE	BWW, BACKWASH WASTE	
300	FILTER BACKWASH WASTE - YARD PIPE	BACKWASH WASTE	BWW	14"	B	PVC, C905 DR 32.5	33 05 01.09B	--	LIGHT BROWN	WHITE	BWW, BACKWASH WASTE	
300	FILTER BACKWASH WASTE	BACKWASH WASTE	BWW	ALL	EN, EXI, EXE, S	CLDI	40_27_00.01	LIGHT BROWN	LIGHT BROWN	WHITE	BWW, BACKWASH WASTE	
300	GAC CARBON SLURRY	CARBON SLURRY	CBS	ALL	EXI	CARBON STEEL, LINED	40 27 00.05B	BLACK	BLACK	WHITE	CBS, CARBON SLURRY	
300	CARBON DIOXIDE GAS	CARBON DIOXIDE GAS	CD	ALL	EXE, EXI	316 SS, SCH 10S	40_27_00.08	--	BLUE	WHITE	CD, CARBON DIOXIDE GAS	
300	CARBON DIOXIDE SOLUTION	CARBONATED WATER	CDS	ALL	EXI	316 SS, SCH 10S	40_27_00.08	--	BLUE	WHITE	CDS, CARBONATED WATER	
300	DOWNSTREAM OF FLOC BASINS - YARD PIPE	CLARIFIED WATER	CLW	>3"	B	CLDI	40_27_00.01	AQUA	AQUA	BLACK	CLW, CLARIFIED WATER	
300	DOWNSTREAM OF RAPID MIX SYSTEM	COAGULATED WATER	COW	>3"	EN, EXI, EXE, S	CLDI	40_27_00.01	BLUE	BLUE	WHITE	CW, COAGULATED WATER	
300	BUILDING POTABLE WATER	COLD WATER	CW	<3"	EN, EXI, EXE, S	COPPER	40_27_00.13	DARK BLUE	GREEN	WHITE	CW, COLD WATER (POTABLE)	
300	FILTER EFFLUENT	FILTER EFFLUENT	FE	ALL	EN, EXI, EXE, S	CLDI	40_27_00.01	LIGHT GRAY	BLUE	WHITE	FE, FILTER EFFLUENT	
300	FILTER EFFLUENT - YARD PIPE	FILTER EFFLUENT	FE	24"	B	PVC, C905 DR 32.5	33 05 01.09B	--	BLUE	WHITE	FE, FILTER EFFLUENT	
300	FILTER INFLUENT	FILTER INFLUENT	FI	ALL	EN, EXI, EXE, S	CLDI	40_27_00.01	LIGHT GRAY	BLUE	WHITE	FI, FILTER INFLUENT	
300	FILTER TO WASTE	FILTER TO WASTE	FTW	ALL	EN, EXI, EXE, S	CLDI	40_27_00.01	LIGHT GRAY	BLUE	WHITE	FTW, FILTER TO WASTE	
300	FILTER TO WASTE - YARD PIPE	FILTER TO WASTE	FTW	10"	B	PVC, C900 DR 32.5	33 05 01.09B	--	BLUE	WHITE	FTW, FILTER TO WASTE	
300	GAC EFFLUENT	GAC EFFLUENT	GE	ALL	EN, EXI, EXE, S	CLDI	40_27_00.01	LIGHT GRAY	BLUE	WHITE	GE, GAC EFFLUENT	
300	GAC INFLUENT	GAC INFLUENT	GI	ALL	EN, EXI, EXE, S	CLDI	40_27_00.01	LIGHT GRAY	BLUE	WHITE	GI, GAC INFLUENT	
300	LAB WATER/SHOP WATER	NON-POTABLE WATER	NPW	<=4"	B, EN, EXE, EXI	PVC, SCH 80	40_27_00.10	--	GREEN	WHITE	W2, NON-POTABLE WATER	
300	DRAIN SYSTEM	DRAIN (PROCESS)	PD	ALL	B, EN, EXE, EXI, S	PVC, SCH 80	40_27_00.10	--	GREEN	WHITE	PD, PROCESS DRAIN	
300	DRAIN SYSTEM - YARD PIPE	DRAIN (PROCESS)	PD	ALL	B	PVC, C900 DR 32.5	33 05 01.09B	--	GREEN	WHITE	PD, PROCESS DRAIN	
300	SAMPLE PUMP PIPING	SAMPLE	SA	<1"	EN, EXI, EXE, S	PVC, SCH 80	40_27_00.10	--	BLUE	WHITE	SA, SAMPLE	
300	SAMPLE PUMP PIPING	SAMPLE	SA	ALL	EN, EXI, EXE, S	PVC, SCH 80	40_27_00.10	--	BLUE	WHITE	SA, SAMPLE	
300	POTABLE WATER SUPPLY - YARD PIPE	W1 (POTABLE) WATER	W1, PW	6"	B	PVC, C905 DR 25	33 05 01.09B	--	BLUE	WHITE	W1, POTABLE WATER	
360	BACKWASH SUPPLY PIPING - YARD PIPE	BACKWASH SUPPLY	BWS	14"	B	PVC, C905 DR 25	33 05 01.09B	--	BLUE	WHITE	BWS, BACKWASH SUPPLY	
360	BACKWASH SUPPLY PIPING	BACKWASH SUPPLY	BWS	ALL	EN, EXI, EXE, S	CLDI	40_27_00.01	BLUE	BLUE	WHITE	BWS, BACKWASH SUPPLY	
360	SURGE TANK AIR SUPPLY	COMPRESSED AIR	CA	ALL	EXI	COPPER	40_27_00.13	DARK GREEN	GREEN	WHITE	CA, COMPRESSED AIR	
360	POTABLE WATER SUPPLY	COLD WATER	CW	ALL	EXI	CARBON STEEL, LINED	40 27 00.05B	DARK BLUE	GREEN	WHITE	CW, COLD WATER (POTABLE)	
360	POTABLE WATER SUPPLY	COLD WATER	CW	ALL		COPPER	40_27_00.13	DARK BLUE	GREEN	WHITE	CW, COLD WATER (POTABLE)	
360	FILTER EFFLUENT - YARD PIPE	FILTER EFFLUENT	FE	24"	B	PVC, C905 DR 32.5	33 05 01.09B	--	BLUE	WHITE	FE, FILTER EFFLUENT	
360	FW PUMP DISCHARGE - YARD PIPE	FINISHED WATER	FW	20"	B	PVC, C905 DR 18	33 05 01.09B	--	DARK BLUE	WHITE	FW, FINISHED WATER	
360	FW PUMP DISCHARGE	FINISHED WATER	FW	ALL	EXI	CARBON STEEL, LINED	40 27 00.05B	DARK BLUE	DARK BLUE	WHITE	FW, FINISHED WATER	
360	FWPS W2	NON-POTABLE WATER	NPW	ALL	EN, EXI, EXE, S	PVC, SCH 80	40_27_00.10	--	GREEN	WHITE	W2, NON-POTABLE WATER	
360	FWPS OVERFLOW PIPING - YARD PIPE	OVERFLOW	OF	24"	B	PVC, C905 DR 32.5	33 05 01.09B	--	GREEN	WHITE	OF, OVERFLOW	
360	DRAIN SYSTEM - YARD PIPE	DRAIN (PROCESS)	PD	ALL	B	PVC, C900 DR 32.5	33 05 01.09B	--	GREEN	WHITE	PD, PROCESS DRAIN	
360	RECYCLE FROM FWPS - YARD PIPE	RECYCLE	RCY	14"	B	PVC, C905 DR 25	33 05 01.09B	--	BLUE	WHITE	RCY, RECYCLED WATER	
360	POTABLE WATER SUPPLY - YARD PIPE	W1 (POTABLE) WATER	W1, PW	6"	B	PVC, C905 DR 25	33 05 01.09B	--	BLUE	WHITE	W1, POTABLE WATER	
380		POLYMER, ANIONIC	APO	ALL	B, EN, EXE, EXI	PFA (TUBING)	40_27_00.22	--	ORANGE	BLACK	APO, POLYMER, ANIONIC	
380		POLYMER, CATIONIC	CPO	ALL	B, EN, EXE, EXI	PFA (TUBING)	40_27_00.22	--	ORANGE	BLACK	CPO, POLYMER, CATIONIC	
380		FERRIC CHLORIDE, 40%	FC	ALL	B, EN, EXE, EXI	PFA (TUBING)	40_27_00.22	--	ORANGE	BLACK	FC, FERRIC CHLORIDE	
380		DRAIN (PROCESS)	PD	ALL	B, EN, EXE, EXI, S	PVC, SCH 80	40_27_00.10	--	GREEN	WHITE	PD, PROCESS DRAIN	
380		PHOSPHORIC ACID	PHA	ALL	B, EN, EXE, EXI	PFA (TUBING)	40_27_00.22	--	ORANGE	BLACK	PHA, PHOSPHORIC ACID	
380		SODIUM BISULFITE, 38%	SBS	ALL	B, EN, EXE, EXI	PFA (TUBING)	40_27_00.22	--	ORANGE	BLACK	SM, 38% SODIUM BISULFITE	
380		SULFURIC ACID, 93%	SFA	ALL	B, EN, EXE, EXI	PFA (TUBING)	40_27_00.22	--	YELLOW	BLACK	SU, SULFURIC ACID	
380		SODIUM HYDROXIDE, 50%	SH	ALL	B, EN, EXE, EXI	PFA (TUBING)	40_27_00.22	--	YELLOW	BLACK	SH, 50% SODIUM HYDROXIDE	
380		SODIUM HYPOCHLORITE, 10%	SHC	ALL	B, EN, EXE, EXI	PFA (TUBING)	40_27_00.22	--	YELLOW	BLACK	SHC, 10% SODIUM HYPOCHLORITE	
380	POTABLE WATER SUPPLY - YARD PIPE	W1 (POTABLE) WATER	W1, PW	6"	B	PVC, C905 DR 25	33 05 01.09B	--	BLUE	WHITE	W1, POTABLE WATER	
420	GAC BACKWASH WASTE/FTW - YARD PIPE	BACKWASH WASTE	BWW	8"	B	PVC, C900 DR 32.5	33 05 01.09B	--	LIGHT BROWN	WHITE	BWW, BACKWASH WASTE	
420	FILTER BACKWASH WASTE - YARD PIPE	BACKWASH WASTE	BWW	14"	B	PVC, C905 DR 32.5	33 05 01.09B	--	LIGHT BROWN	WHITE	BWW, BACKWASH WASTE	
420	FILTER BACKWASH WASTE	BACKWASH WASTE	BWW	ALL	EXE, S	CLDI	40_27_00.01	LIGHT BROWN	LIGHT BROWN	WHITE	BWW, BACKWASH WASTE	
420	DECANT WATER - YARD PIPE	DECANTED WATER	DEC	20"	B	PVC, C905 DR 32.5	33 05 01.09B	--	BLUE	WHITE	DCT, DECANTED WATER	
420		DECANTED WATER	DEC	ALL	EXE, S	CLDI	40_27_00.01	LIGHT GRAY	BLUE	WHITE	DCT, DECANTED WATER	
420	FILTER TO WASTE - YARD PIPE	FILTER TO WASTE	FTW	10"	B	PVC, C900 DR 32.5	33 05 01.09B	--	BLUE	WHITE	FTW, FILTER TO WASTE	
420		FILTER TO WASTE	FTW	ALL	EXE, S	CLDI	40_27_00.01	LIGHT GRAY	BLUE	WHITE	FTW, FILTER TO WASTE	
420	LIQUID RESIDUALS, COMBINED LINE - YARD PIPE	LIQUID RESIDUALS	LR	20"	B	PVC, C905 DR 32.5	33 05 01.09B	--	LIGHT BROWN	WHITE	LR, LIQUID RESIDUALS	
420	LIQUID RESIDUALS, COMBINED LINE	LIQUID RESIDUALS	LR	20"	B, S	PVC, C900 DR 32.5	33 05 01.09B	--	LIGHT BROWN	WHITE	LR, LIQUID RESIDUALS	
420	FWPS OVERFLOW PIPING - YARD PIPE	OVERFLOW	OF	24"	B	PVC, C905 DR 32.5	33 05 01.09B	--	GREEN	WHITE	OF, OVERFLOW	
420	FWPS OVERFLOW PIPING	OVERFLOW	OF	ALL	EXE, S	CLDI	40_27_00.01	LIGHT GRAY	GREEN	WHITE	OF, OVERFLOW	
420	DRAIN SYSTEM - YARD PIPE	DRAIN (PROCESS)	PD	ALL	B	PVC, C900 DR 32.5	33 05 01.09B	--	GREEN	WHITE	PD, PROCESS DRAIN	
420		DRAIN (PROCESS)	PD	ALL	EXE, S	PVC, SCH 80	40_27_00.10	--	GREEN	WHITE	PD, PROCESS DRAIN	
420	RAW WATER FLUSHING - YARD PIPE	RAW WATER	RW	16"	B	PVC, C905 DR 25	33 05 01.09B	--	OLIVE GREEN	WHITE	RW, RAW WATER	
420	SLUDGE WASTE TO SOLID DRYING BED - YARD PIPE	SLUDGE WASTE	SLG	6"	B	PVC, C900 DR 25	33 05 01.09B	--	YELLOW	BLACK	SLW, SLUDGE WASTE	
420		UNTHICKENED SLUDGE	USL	ALL	EXE, S	CLDI	40_27_00.01	DARK BROWN	GREEN	WHITE	USL, UNTHICKENED SLUDGE	
420	UNTHICKENED SLUDGE - YARD PIPE	UNTHICKENED SLUDGE	USL	8"	B	PVC, C900 DR 32.5	33 05 01.09B	--	GREEN	WHITE	USL, UNTHICKENED SLUDGE	
420	POTABLE WATER SUPPLY - YARD PIPE	W1 (POTABLE) WATER	W1, PW	6"	B	PVC, C905 DR 25	33 05 01.09B	--	BLUE	WHITE	W1, POTABLE WATER	
440	SLUDGE WASTE TO SOLID DRYING BED - YARD PIPE	SLUDGE WASTE	SLG	6"	B	PVC, C900 DR 25	33 05 01.09B	--	YELLOW	BLACK	SLW, SLUDGE WASTE	

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FACILITY #	LINE DESCRIPTION	SERVICE	FLOW STREAM IDENTIFICATION	SIZE, INCHES	EXPOSURE	PIPING MATERIAL	PIPE SPEC SECTION	PIPE COATING COLOR (09_90_00)	PIPE LABELING FIELD COLOR (10 14 00)	PIPE LABELING TEXT COLOR (10 14 00)	LABEL TEXT (10 14 00)	NOTES
440		SLUDGE WASTE	SLG	ALL	EXE, S	CLDI	40_27_00.01	DARK BROWN	YELLOW	BLACK	SLW, SLUDGE WASTE	
440	POTABLE WATER SUPPLY - YARD PIPE	W1 (POTABLE) WATER	W1, PW	6"	B	PVC, C905 DR 25	33 05 01.09B	--	BLUE	WHITE	W1, POTABLE WATER	
460	DECANT WATER - YARD PIPE	DECANTED WATER	DEC	20"	B	PVC, C905 DR 32.5	33 05 01.09B	--	BLUE	WHITE	DCT, DECANTED WATER	
460		DECANTED WATER	DEC	>3"	EN, EXI, EXE, S	CLDI	40_27_00.01	LIGHT GRAY	BLUE	WHITE	DCT, DECANTED WATER	
460	ENVIRONMENTAL DISCHARGE - YARD PIPE	ENVIRONMENTAL DISCHARGE	EVD	6"	B	PVC, C900 DR 25	33 05 01.09B	--	BLUE	WHITE	EVD, ENVIRONMENTAL DISCHARGE	
460		ENVIRONMENTAL DISCHARGE	EVD	>3"	EN, EXI, EXE, S	CLDI	40_27_00.01	LIGHT GRAY	BLUE	WHITE	EVD, ENVIRONMENTAL DISCHARGE	
460	RECYCLE FROM DECANT WATER PS - YARD PIPE	RECYCLE	RCY	6"	B	PVC, C900 DR 25	33 05 01.09B	--	BLUE	WHITE	RCY, RECYCLED WATER	
460	RECYCLE FROM DECANT WATER PS	RECYCLE	RCY	>3"	EN, EXI, EXE, S	CLDI	40_27_00.01	LIGHT GRAY	BLUE	WHITE	RCY, RECYCLED WATER	
460		SAMPLE	SA	ALL	B, EN, EXE, EXI, S	PVC, SCH 80	40_27_00.10	--	BLUE	WHITE	SA, SAMPLE	
460	POTABLE WATER SUPPLY - YARD PIPE	W1 (POTABLE) WATER	W1, PW	6"	B	PVC, C905 DR 25	33 05 01.09B	--	BLUE	WHITE	W1, POTABLE WATER	
500	FIRE PUMP DISCHARGE - YARD PIPE	FIRE SPRINKLER WATER	FS	8"	B	PVC, C900 DR 25	0	--	RED	WHITE	FS, FIRE SPRINKLER WATER	
500	FIRE PUMP DISCHARGE	FIRE SPRINKLER WATER	FS	ALL	EXI	CARBON STEEL	21_13_13i	RED	RED	WHITE	FS, FIRE SPRINKLER WATER	
		LEGEND: B=BURIED, EXI=EXPOSED INTERIOR, EXE=EXPOSED EXTERIOR S=SUBMERGED, EN=CONCRETE ENCASED G=GRAVITY, H=HYDROSTATIC, I=IN-SERVICE, P=PNEUMATIC, PC=UNIFORM PLUMBING CODE, NA=NOT APPLICABLE, IPC=INTERNATIONAL PLUMBING CODE, HP=HYDROSTATIC-PNEUMATIC										

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SECTION 40 27 00.01
CEMENT-MORTAR-LINED
DUCTILE IRON PIPE AND FITTINGS

Item	Description
General	Materials in contact with potable water shall conform to NSF 61 acceptance. Pipe manufacturer shall submit certification that source manufacturing facility has been producing ductile iron pipe of the specified diameters, dimensions, and standards for a period of not less than 10 years. Testing of pipe required by AWWA A21.51 shall be conducted in testing and laboratory facilities located in the USA and operating under USA laws and regulations. Pipe shall be handled during manufacture and shipped without nesting (without insertion of one pipe inside another).
Pipe	Buried Liquid Service Using, Mechanical, or Proprietary Restrained Joints: AWWA C111/A21.11, and AWWA C151/A21.51, pressure class conforming to Table 5 and Table 7 for Type 4 trench, 250 psi minimum working pressure. Follower glands shall be ductile iron. Exposed Pipe Using Grooved End and Flange Joints: AWWA C115/A21.15, thickness Class 53 minimum, 250 psi minimum working pressure.
Lining	Cement-mortar with bitumastic seal coat: [VC1]AWWA C104/A21.4.
Fittings	Lined and coated same as pipe. Mechanical: AWWA C110/A21.10, AWWA C111/A21.11, and AWWA C153/A21.53 ductile iron, 250 psi minimum working pressure. Follower glands shall be ductile iron. Proprietary Restrained: AWWA C110/A21.10, AWWA C111/A21.11, and AWWA C153/A21.53, ductile iron, 250 psi minimum working pressure. Restraint shall be achieved with removable metal elements fitted between a welded bar on the pipe barrel and the inside of the joint bell or fitting sizes smaller than 16 inches may be mechanical joint, restrained by anchor gland followers, ductile iron anchor type, wedge action, with break-off tightening bolts. Assembled joints shall be rated for deflection in operation at rated pressure. Rated deflection shall be not less than 1-1/2 degrees for 36-inch and smaller pipe. Rated deflection shall be not less than 1/2 degree for 42-inch and larger pipe. Clow Corp., American Cast Iron Pipe Co., U.S. Pipe. Restrained joints relying on metal teeth molded into the gasket to prevent joint separation under pressure will not be accepted.

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SECTION 40 27 00.01
CEMENT-MORTAR-LINED
DUCTILE IRON PIPE AND FITTINGS

Item	Description
	Grooved End: AWWA C606 and AWWA C110/A21.10, ductile iron, 250 psi minimum working pressure; Victaulic. Flange: AWWA C110/A21.10 ductile iron, faced and drilled, Class 125 flat face or ASME B16.1, Class 250 raised face. Gray cast iron will not be allowed.
Joints	Mechanical: 250 psi minimum working pressure. Proprietary Restrained: 150 psi minimum working pressure. Clow Corp., Super-Lock; American Cast Iron Pipe Co., Flex-Ring or Lok-Ring; U.S. Pipe, TR Flex. Clow Corp., American Cast Iron Pipe Co., U.S. Pipe. Restrained joints relying on metal teeth molded into the gasket to prevent joint separation under pressure will not be accepted. Grooved End: Rigid type radius cut conforming to AWWA C606, 250 psi minimum working pressure; Victaulic. Flange: Class 125 flat face, or Class 250 raised face, ductile iron, threaded conforming to AWWA C115/A21.15. Gray cast iron will not be allowed. Branch connections 3 inches and smaller, shall be made with service saddles as specified in Section 40 27 01, Process Piping Specialties.
Couplings	Grooved End: 250 psi minimum working pressure, malleable iron per ASTM A47/A47M or ductile iron per ASTM A536; Victaulic. Grooved End Adapter Flanges: 250 psi minimum working pressure, malleable iron per ASTM A47/A47M or ductile iron per ASTM A536; Victaulic.
Bolting	Mechanical, Proprietary Restrained, and Grooved End Joints: Manufacturer's standard. Class 125 Flat-Faced Flange: ASTM A307, Grade A carbon steel hex head bolts, ASTM A563, Grade A carbon steel hex head nuts and ASTM F436/F436M hardened steel washers at nuts and bolt heads. Achieve 40 percent to 60 percent of bolt minimum yield stress. Flanged Joints in Sumps, Wet Wells, Submerged, Encased, Buried, and Wetted Installations: Type 316 stainless steel, ASTM A320/A320M, Grade B8M hex head bolts; ASTM A194/A194M, Grade 8M hex nuts and ASTM F436/F436M Type 3 alloy washers at nuts and bolt heads.

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SECTION 40 27 00.01 CEMENT-MORTAR-LINED DUCTILE IRON PIPE AND FITTINGS	
Item	**Description**
	Achieve 40 percent to 60 percent of bolt minimum yield stress.
Gaskets	General: Gaskets in contact with potable water shall be NSF 61 certified. Mechanical, and Proprietary Restrained Joints; Water and Sewage Service: Rubber conforming to AWWA C111/A21.11. Mechanical, and Proprietary Restrained Joints; Hot Air Service: EPDM or Viton and conforming to AWWA C111/A21.11. Grooved End Joints: Halogenated butyl conforming to ASTM D2000 and AWWA C606. Flanged, Water, Sewage and Hot Air Services: 1/8-inch-thick, homogeneous black rubber (EPDM), hardness 60 (Shore A), rated to 275 degrees F, conforming to ASME B16.21 and ASTM D2000 4CA 415 A25 B35 C32 EA14 F19. Full face for Class 125 flat-faced flanges, flat-ring type for Class 250 raised-face flanges. Blind flanges shall be gasketed covering entire inside face with gasket cemented to blind flange. Gasket pressure rating to equal or exceed the system hydrostatic test pressure.
Joint Lubricant	Manufacturer's standard.
Insulated Connections	See Section[VC2] 40 27 00 Process Piping -- General.

END OF SECTION

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SECTION 40 27 00.03 CARBON STEEL PIPE AND FITTINGS—GENERAL SERVICE		
Item	**Size**	**Description**
Pipe	All	Black carbon steel, ASTM A106/A106M, Grade B seamless or ASTM A53/A53M, Grade B seamless or ERW. Threaded, butt-welded, grooved end, and flanged joints:
	Screwed:	
	2" & smaller	Schedule 40.
	Welded:	
	2-1/2" thru 10"	Schedule 40.
	12" thru 16"	Schedule 30.
	18" thru 24"	Schedule 20.
	Grooved:	
	2-1/2" thru 6"	Schedule 40.
	8" thru 12" inch	Schedule 30.
	14"	Standard weight.
Joints	2" & smaller	Threaded or flanged at valves and equipment or grooved end meeting the requirements of AWWA C606.
	2-1/2" & larger	Butt-welded or flanged at valves and equipment, or grooved end meeting the requirements of AWWA C606.
Fittings	2" & smaller	Threaded: 150- or 300-pound malleable iron, ASTM A197/A197M or ASTM A47/A47M, dimensions in accordance with ASME B16.3. Fire sprinkler fittings to be UL listed. Grooved End: Malleable iron ASTM A47/A47M or ductile iron ASTM A536, grooved ends to accept couplings without field preparation. Victaulic Co.; Anvil International, Inc., Gruvlok.

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SECTION 40 27 00.03 CARBON STEEL PIPE AND FITTINGS—GENERAL SERVICE		
Item	**Size**	**Description**
	2-1/2" & larger	Butt Welded: Wrought carbon steel butt-welding, ASTM A234/A234M, Grade WPB meeting the requirements of ASME B16.9; fitting wall thickness to match adjoining pipe; long radius elbows unless shown otherwise. Grooved End: Malleable iron ASTM A47/A47M, ductile iron ASTM A536, forged steel ASTM A234/A234M, or factory fabricated from ASTM A53/A53M pipe. Grooved ends to accept couplings without field preparation. Victaulic Co.; Anvil International, Inc., Gruvlok; Shurjoint Piping Products.
Branch Connections	2" & smaller	For threaded pipe: Threaded, straight, or reducing tees in conformance with Fittings specified above. For welded or grooved pipe, use threadolet.
	2-1/2" & larger	Butt-welding or grooved end tee in conformance with Fittings specified above.
Flanges	2" & smaller	Forged carbon steel, ASTM A105/A105M, Grade II, ASME B16.5 Class 150 or Class 300 socket-weld or threaded, 1/16-inch raised face.

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SECTION 40 27 00.03 CARBON STEEL PIPE AND FITTINGS—GENERAL SERVICE		
Item	**Size**	**Description**
	2-1/2" & larger	Butt-Welded Systems: Forged carbon steel, ASTM A105/A105M, ASME B16.5 Class 150 or Class 300 slip-on or welding neck, 1/16-inch raised face; weld neck bore to match pipe internal diameter. Use weld neck flanges when abutting butt-weld fittings. Weld slip-on flanges inside and outside. Grooved End Adapter Flange: Malleable iron ASTM A47/A47M or ductile iron ASTM A536. Victaulic Style 741 or 743; Anvil International, Inc., Gruvlok Figure 7012 or 7013; Shurjoint Model 7041-A. Include stainless steel washer plates as required for mating to serrated faces and lined valves and equipment. Cast Iron Mating Flange: AWWA C207, Class D or E, hub or ring type to mate with ASME B16.1, Class 125 cast-iron flange. AWWA C207 Class F hub type or ASTM A105/A105M, ASME B16.5 Class 300 to mate with ASME B16.1 Class 250 cast-iron flange.
Unions	2" & smaller	Threaded malleable iron, ASTM A197/A197 or ASTM A47/A47M, 150- or 300-pound WOG, meeting the requirements of ASME B16.3.
Couplings	2-1/2" & larger	Grooved End: Rigid joint malleable iron, ASTM A47/A47M or ductile iron, ASTM A536. Victaulic Co.; Anvil International, Inc., Gruvlok; Shurjoint Piping Products. Screwed End: Malleable iron, ASTM A197/A197M or ASTM A47/A47M.

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SECTION 40 27 00.03 CARBON STEEL PIPE AND FITTINGS—GENERAL SERVICE		
Item	**Size**	**Description**
Bolting	All	Flanges: Carbon steel ASTM A307, Grade A hex head bolts; ASTM A563, Grade A hex head nuts and ASTM F436/F436M hardened steel washers at nuts and bolt heads. Achieve 40 percent to 60 percent of bolt minimum yield stress. When mating flange on equipment is cast iron and gasket is flat ring, provide ASTM A307, Grade B hex head bolts; ASTM A563, Grade A heavy hex nuts and ASTM F436/F436M hardened steel washers at nuts and bolt heads. Achieve 40 percent to 60 percent of bolt minimum yield stress. Grooved End Couplings: Carbon steel, ASTM A183 bolts and nuts, 110,000 psi minimum tensile strength. Flanged Joints in Sumps, Wet Wells, and Submerged and Wetted Installations: Type 316 stainless steel, ASTM A320/A320M, Grade B8M hex head bolts; ASTM A194/A194M, Grade 8M hex nuts and ASTM F436/F436M Type 3 alloy washers at nuts and bolt heads. Achieve 40 percent to 60 percent of bolt minimum yield stress.

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SECTION 40 27 00.03 CARBON STEEL PIPE AND FITTINGS—GENERAL SERVICE		
Item	**Size**	**Description**
Gaskets	All flanges	Water, Steam, and Air Services: 1/16-inch-thick, compressed inorganic fiber with nitrile binder, rated 400 degrees F. continuous. Fuel Gas Service: 1/8-inch-thick, homogeneous black rubber (EPDM), hardness 60 (Shore A), rated 250 degrees F. continuous and conforming to ASME B16.21 and ASTM D1330, Steam Grade. Blind flanges shall be gasketed covering the entire inside face with the gasket cemented to the blind flange. Grooved Couplings: EPDM per ASTM D2000 for water and oil-free air to 230 degrees F, nitrile for oil vapor in air and oil services to 180 degrees F. NSF 61 approved for potable water service.
Thread Lubricant	2" & smaller	General Service: 100 percent virgin PTFE Teflon tape. Fuel Gas Service: Yellow Teflon tape designed for fuel gas service, Air Force A-A-58092, AA Thread Seal Tape, Inc.
Insulated Connections	All	See Section 40 27 00 Process Piping -- General.

END OF SECTION

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SECTION 40 27 00.05 GLASS-LINED CARBON STEEL PIPE AND FITTINGS	
Item	**Description**
Pipe	Black carbon steel; ASTM A106/A106M, Grade B seamless or ASTM A53/A53M, Grade B seamless or ERW: 10" & smaller Schedule 40.
Lining	Glass: Completely fused above 1,400 degrees F, 6 to 10 mils thick, defects which expose base metal not greater than 0.1 percent of total lined surface, hardness greater than 5 on the Mohs scale, lining bonded sufficiently to withstand a metal strain of 0.001-inch/inch without damage to the glass lining, finished lined pipe not to deviate more than 0.0125-inch per foot of length from a centerline perpendicular to the flange face or square end of the pipe. Water Works Supply Co., Ferrock MEH-32; Ceramic Coating Co., SL-31; Ervite Corp., SG-14.
Fittings	Lined same as pipe. Grooved End: AWWA C110/A21.10 and AWWA C606 malleable iron ASTM A47/A47M or ductile ASTM A536 or steel, 150-psi minimum working pressure. Victaulic; Anvil International, Inc., Gruvlok. Flanged: Carbon steel, ASTM A234/A234M, Grade WPB, thickness to match adjoining pipe; elbows long radius, unless shown otherwise.
Joints	Grooved End: Rigid type radius cut conforming to AWWA C606. Victaulic; Anvil International, Inc., Gruvlok. Flanged: 125-pound flat face or 250-pound raised face ductile iron threaded conforming to AWWA C115/A21.15.
Couplings	Grooved End: 150-psi minimum working pressure malleable iron per ASTM A47/ASTM A47M or ductile iron per ASTM A536. Victaulic; Anvil International, Inc., Gruvlok. Grooved End Adapter Flanges: 125-pound malleable iron per ASTM A47/A47M or ductile iron per ASTM A536. Victaulic; Anvil International, Inc., Gruvlok.
Flanges	Forged carbon steel, slip-on or weld neck ASTM A105/A105M, 150- or 300-pound. Provide weld neck flanges when abutting butt-weld fittings. Weld neck bore to match pipe. Weld prior to lining only.

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SECTION 40 27 00.05 GLASS-LINED CARBON STEEL PIPE AND FITTINGS	
Item	**Description**
Bolting	ASTM A307, Grade A carbon steel hex head bolts and ASTM A563, Grade A carbon steel hex head nuts. Grooved End Coupling: Carbon steel, ASTM A183 bolts and nuts.
Gaskets	Grooved End Joints: Halogenated butyl conforming to ASTM D2000 and AWWA C606 for water and air; nitrile for oil. Flanged, Glass Lined Pipe and Fittings: 1/8-inch-thick, homogeneous black rubber (EPDM), hardness 60-80 (Shore A), rated to 275 degrees F, conforming to ASME B16.21 and ASTM D2000. Blind flanges shall be gasketed covering the entire inside face with the gasket cemented to the blind flange.
Joint Lubricant	Manufacturer's standard.

END OF SECTION

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SECTION 40 27 00.08 STAINLESS STEEL PIPE AND FITTINGS—GENERAL SERVICE		
Item	**Size**	**Description**
Pipe	2-1/2" & smaller	Schedule 40S: ASTM A312/A312M, Type 316 seamless, pickled and passivated.
	3" thru 6"	Schedule 10S: ASTM A778, “as-welded” grade, Type 316L, pickled and passivated.
	8" & larger	Schedule 5S: ASTM A778, “as-welded” grade, Type 316L, pickled and passivated.
Tubing	All	ASTM A269, Type 316 stainless steel, seamless, fully annealed hydraulic tubing, 0.065-inch wall thickness minimum.
Joints	1-1/2" & smaller	Threaded or flanged at equipment as required or shown.
	2" & larger	Butt-welded or flanged at valves and equipment.
Tubing Joints	All	Flareless compression fitting
Fittings	1-1/2" & smaller	Threaded: Forged 1,000 CWP minimum, ASTM A182/A182M, Grade F316 or cast Class 150, ASTM A351/A351M, Grade CF8M/316.
	2" & 2-1/2"	Butt Welded: ASTM A403/A403M, Grade WP316L conforming to ASME B16.9 and MSS SP 43, annealed, pickled and passivated; fitting wall thickness to match adjoining pipe; long radius elbows, unless shown otherwise.
	3" & larger	Butt-Welded: ASTM A774/A774M Grade 316L conforming to MSS SP 43, “as-welded” grade, pickled and passivated; fitting wall thickness to match adjoining pipe; long radius elbows, unless shown otherwise.
Tubing Fittings	All	Flareless Compression Type Forged: ASTM A182/A182M, Grade F316, Parker-Hannifin Ferulok, Flodar BA Series.

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SECTION 40 27 00.08 STAINLESS STEEL PIPE AND FITTINGS—GENERAL SERVICE		
Item	**Size**	**Description**
Branch Connections	1-1/2" & smaller	Tee or reducing tee in conformance with fittings above.
	2" & larger	Butt-welding tee or reducing tee in accordance with fittings above.
Tubing Branch Connections	All	Compression type tees or reducing tees in accordance with Tubing Fittings above.
Flanges	All	Forged Stainless Steel: ASTM A182/A182M, Grade F316L, ASME B16.5 Class 150 or Class 300, slip-on weld neck or raised face. Weld slip-on flanges inside and outside. Cast Carbon Steel: ASTM A216/A216M Grade WCA, drilled, ASME B16.5 Class 150 or Class 300 Van Stone Type with stainless steel stub ends, ASTM A240 Type 316L “as-welded grade”, conforming to MSS SP 43, wall thickness same as pipe. Blind Flanges, exposed to the atmosphere and not buried nor immersed in liquid, may be either stainless steel or Class 125 ductile iron or Class 150 carbon steel with gaskets as specified herein.
Unions	2" & smaller	Threaded Forged: ASTM A182/A182M, Grade F316, 2,000-pound or 3,000-pound WOG, integral ground seats, AAR design meeting the requirements of ASME B16.11, bore to match pipe.

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SECTION 40 27 00.08 STAINLESS STEEL PIPE AND FITTINGS—GENERAL SERVICE		
Item	**Size**	**Description**
Bolting	All	Forged Flanges: Type 316 stainless steel, ASTM A320/A320M Grade B8M hex head bolts, ASTM A194/A194M Grade 8M hex head nuts and ASTM F436/F436M Type 3 alloy washers at nuts and bolt heads. Achieve 40 percent to 60 percent of bolt minimum yield stress. Van Stone Flanges and anywhere mating flange on equipment is cast iron and gasket is flat ring: Carbon steel ASTM A307 Grade B hex head bolts, ASTM A563 Grade A hex head nuts and ASTM F436/F436M hardened steel washers at nuts and bolt heads. Achieve 40 percent to 60 percent of bolt minimum yield stress.
Gaskets	All Flanges	Flanged, Water, Hot Air, Fuel Gas and Sewage Services: 1/8 inch thick, homogeneous black rubber (EPDM), hardness 60 (Shore A), rated to 250 degrees F. continuous and conforming to ASME B16.21 and ASTM D1330, Steam Grade. Blind flanges shall be gasketed covering entire inside face with gasket cemented to blind flange.
Thread Lubricant	2" & smaller	General Service: 100 percent virgin PTFE Teflon tape. Fuel Gas Service: Yellow Teflon tape designed for fuel gas service, Air Force A-A-58092, AA Thread Seal Tape, Inc.

END OF SECTION

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SECTION 40 27 00.10 POLYVINYL CHLORIDE (PVC) PIPE AND FITTINGS		
Item	**Size**	**Description**
General	All	Materials in contact with potable water shall conform to NSF 61 acceptance.
Pipe	All	Schedule 80 PVC: Type I, Grade I or Class 12454-B conforming to ASTM D1784 and ASTM D1785. Pipe shall be manufactured with titanium dioxide for ultraviolet protection. Threaded Nipples: Schedule 80 PVC.
Fittings	All	Schedule to Match Pipe Above: ASTM D2466 and ASTM D2467 for socket weld type and Schedule 80 ASTM D2464 for threaded type. Fittings shall be manufactured with titanium dioxide for ultraviolet protection.
Joints	All	Solvent socket weld except where connection to threaded valves and equipment may require future disassembly.
Flanges	All	One-piece, molded hub type PVC flat face flange in accordance with Fittings above, ASME B16.1, Class 125 drilling
Bolting	All	Flat Face Mating Flange and In Corrosive Areas: ASTM A193/A193M, Type 316 stainless steel Grade B8M hex head bolts, ASTM A194/A194M Grade 8M hex head nuts and ASTM F436 Type 3 alloy washers at nuts and bolt heads. Achieve 40 percent to 60 percent of bolt minimum yield stress. With Raised Face Mating Flange: Carbon steel ASTM A307 Grade B square head bolts, ASTM A563 Grade A heavy hex head nuts and ASTM F436 hardened steel washers at nuts and bolt heads. Achieve 40 percent to 60 percent of bolt minimum yield stress.

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SECTION 40 27 00.10 POLYVINYL CHLORIDE (PVC) PIPE AND FITTINGS		
Item	**Size**	**Description**
Gaskets	All	Flat Face Mating Flange: Full faced 1/8-inch-thick Durlon, 9200W RCA, Garlock Gylon 3510. Raised Face Mating Flange: Flat ring 1/8-inch Durlon, 9200W RCA, Garlock Gylon 3510, with filler gasket between OD of raised face and flange OD to protect the flange from bolting moment.
Solvent Cement	All	Socket type joints shall be made employing solvent cement that meets or exceeds the requirements of ASTM D2564 and primer that meets or exceeds requirements of ASTM F656, chemically resistant to the fluid service, and as recommended by pipe and fitting manufacturer, except solvent weld cement for PVC pipe joints in sodium hypochlorite service shall be free of silica filler and shall be certified by the manufacturer to be suitable for that service, IPS Weld-On 724 or approved equal. Certification shall be submitted. Solvent cement and primer shall be listed by NSF 61 for contact with potable water.
Thread Lubricant	All	Teflon Tape.

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SECTION 40 27 00.13 COPPER AND COPPER ALLOY TUBING AND FITTINGS	
Item	**Description**
General	Materials in contact with potable water shall conform to NSF 61 acceptance.
Tubing	Seamless, conforming to ASTM B88 as follows: Water (buried) .....Type K, soft or hard temper Water (exposed).....Type L, hard drawn Domestic hot water .....Type L, hard drawn Compressed air service .....Type L, hard drawn Laboratory air service .....Type L, hard drawn Laboratory vacuum service.....Type L, hard drawn Refrigerant service.....Type L, hard drawn P-Trap priming service .....Type L, soft temper Sample line service .....Type L, hard drawn Laboratory gas service .....Type L, hard drawn
Fittings	ASTM B75 commercially pure wrought copper, socket joint, dimensions conforming to ASME B16.22.
Flanges	Class 150, ASTM B75 commercially pure wrought copper, socket joint, ASME B16.24 standard.
Bolting	ASTM A307, carbon steel, Grade A hex head bolts, ASTM A563 Grade A hex head nuts and ASTM F436/F436M hardened steel washers at nuts and bolt heads. Achieve 40 percent to 60 percent of bolt minimum yield stress.
Gaskets	1/16-inch-thick nonasbestos compression type, full face, Cranite, John Manville.
Solder	Joints 2-1/2 Inch and Smaller: Wire solder (95 percent tin), conforming to ASTM B32 Alloy Grade Sn95. Do not use cored solder. Joints Larger Than 2-1/2 Inch: Wire solder, melt range approximately 440 degrees F to 660 degrees F, conforming to ASTM B32 Alloy Grade HB or HN. Do not use cored solder.

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SECTION 40 27 00.18
POLYVINYLIDENE FLUORIDE (PVDF) PIPE AND FITTINGS

Item	Size	Description
Pipe	All	PVDF: Type I of ASTM D3222, conforming to ASTM D2837. Use unpigmented PVDF resin and size according to SDR system to 230 psi for sizes 3/8 inch to 2-1/2 inches and 150 psi for 3 inches through 12 inches at 73.4°F.
Fittings	All	PVDF as specified under Pipe above. All pressure fittings shall be injection mold for butt fusion.
Joints	All	Butt Fusion. Temperatures, times, and pressures of fusion shall be according to the manufacturer. Pipe joining equipment shall be provided by the pipe and fitting manufacturer.
Flanges	All	Stub end and polypropylene coated steel backing ring with ANSI, 150-pound bolt hole pattern. Follow manufacturers torque and tightening procedures.
Bolting	All	ASTM A193/A193M Rev A Type 316 stainless steel Grade B8M hex head bolts and ASTM A194/A194M Grade 8M hex head nuts.
Gaskets	All	Shall be low torque, full face to ASME B16.5 dimensions and shall have two concentric, convex, molded rings between center hole and bolt hole circle in Teflon-bonded EPDM.

END OF SECTION

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SECTION 40 27 00.22 PERFLUOROALKOXY (PFA) TUBING, FITTINGS AND SECONDARY CONTAINMENT		
PRIMARY TUBING		
Item	**Tube Size**	**Description**
General	All	Materials in contact with potable water shall conform to NSF 61 acceptance.
Tubing	1/4 thru 1 inch	100 percent virgin perfluoroalkoxy (PFA) tubing, high purity. Dupont 450 resin. ASME B31.3, Chapter VII, Category N Fluid
Wall Thickness	1/4 inch 3/8 thru 1 inch	0.047 inch 0.062 inch
Fittings and Unions	All	Virgin PFA wetted parts, thermally flared type fittings with PFA nut.
Joints	All	Thermally flared tubing-to-fitting connection.
Acceptable Manufacturer	All	Parflex/Atlantic Entegris Saint Gobain Performance Plastics. Approved Equal
SECONDARY CONTAINMENT		
Piping	1 thru 4 inch	Schedule 40 PVC: Type I, Grade I or Class 12454-B conforming to ASTM D1784 and ASTM D1785. Pipe shall be manufactured with titanium dioxide for ultraviolet protection. ASME B31.3, Chapter VII, Category N Fluid
Fittings	1 thru 4 inch	Schedule 40 PVC (white), ASTM D2466, Class 12454B, socket-weld, or hot-air formed long radius bends (use fittings wherever possible).
Minimum Bend Radius for Hot-Air Bend	1 thru 1 1/2 inch	12 inches
	2 inch	18 inches
	4 inch	20 inches

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SECTION 40 27 00.22 PERFLUOROALKOXY (PFA) TUBING, FITTINGS AND SECONDARY CONTAINMENT		
PRIMARY TUBING		
Item	**Tube Size**	**Description**
General	All	Materials in contact with potable water shall conform to NSF 61 acceptance.
Flanges	All	Dimensions conform to ANSI B16.5 for steel flanges.
Bolting	All	Flat Face Mating Flange and In Corrosive Areas: ASTM A193/A193M, Type 316 stainless steel Grade B8M hex head bolts, ASTM A194/A194M Grade 8M hex head nuts and ASTM F436 Type 3 alloy washers at nuts and bolt heads. Achieve 40 percent to 60 percent of bolt minimum yield stress. With Raised Face Mating Flange: Carbon steel ASTM A307 Grade B square head bolts, ASTM A563 Grade A heavy hex head nuts and ASTM F436 hardened steel washers at nuts and bolt heads. Achieve 40 percent to 60 percent of bolt minimum yield stress.
Gaskets	All	Flat Face Mating Flange: Full faced 1/8-inch-thick Durlon, 9200W RCA, Garlock Gylon 3510. Raised Face Mating Flange: Flat ring 1/8-inch Durlon, 9200W RCA, Garlock Gylon 3510, with filler gasket between OD of raised face and flange OD to protect the flange from bolting moment.
Unions	All	Socket weld, Schedule 40.

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SECTION 40 27 00.22
PERFLUOROALKOXY (PFA) TUBING, FITTINGS AND SECONDARY CONTAINMENT

PRIMARY TUBING

Item	Tube Size	Description
General	All	Materials in contact with potable water shall conform to NSF 61 acceptance.
Solvent Cement	All	Socket type joints shall be made employing solvent cement that meets or exceeds the requirements of ASTM D2564 and primer that meets or exceeds requirements of ASTM F656, chemically resistant to the fluid service, and as recommended by pipe and fitting manufacturer, except solvent weld cement for PVC pipe joints in sodium hypochlorite service shall be free of silica filler and shall be certified by the manufacturer to be suitable for that service, IPS Weld-On 724 or approved equal. Certification shall be submitted. Solvent cement and primer shall be listed by NSF 61 for contact with potable water.

END OF SECTION

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SECTION 40 27 01
PROCESS PIPING SPECIALTIES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Society of Mechanical Engineers (ASME):
   a. B16.1, Gray Iron Pipe Flanges and Flanged Fittings (Classes 25, 125, and 250).
   b. B16.5, Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24 Metric/Inch Standard.
2. American Water Works Association (AWWA):
   a. C110/A21.10, Ductile-Iron and Gray-Iron Fittings.
   b. C153/A21.53, Ductile-Iron Compact Fittings for Water Service.
   c. C210, Liquid-Epoxy Coating Systems for the Interior and Exterior of Steel Water Pipelines.
   d. C213, Fusion-Bonded Epoxy Coating for the Interior and Exterior of Steel Water Pipelines.
   e. C219, Bolted, Sleeve-Type Couplings for Plain-End Pipe.
   f. Manual M11, Steel Pipe—A Guide for Design and Installation.
3. ASTM International (ASTM):
   a. A153/A153M, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
   b. A276, Standard Specification for Stainless Steel Bars and Shapes.
4. National Fire Protection Association (NFPA): 24, Standard for the Installation of Private Fire Service Mains and Their Appurtenances.
5. NSF International (NSF):
   a. NSF/ANSI 61, Drinking Water System Components - Health Effects.
   b. NSF/ANSI 372, Drinking Water System Components - Lead Content.

1.02 SUBMITTALS

A. Action Submittals:

1. Manufacturer’s data on materials, construction, end connections, ratings, overall lengths, and live lengths (as applicable).
2. Metal Bellows Field Finishing:
   a. Manufacturer’s recommended weld procedures for joining welded carbon steel piping to stainless steel bellows.

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b. Welder qualifications for joining welded carbon steel piping to stainless steel bellows.
c. Product data for field-applied System No. 4, high temperature, epoxy lining and coating in accordance with Section 09 90 00, Painting and Coating.

3. Chemical Injectors:
   a. Type, size, quantity, materials, and model number of each.
   b. Sketch of each showing major parts, main pipe, and dimensions.
   c. Details and model number of each support system and component.
   d. Details and model of connects (for example, service saddle, weld-o-let).

B. Informational Submittals:

1. Coupling Harness:
   a. Details, ratings, calculations and test reports for thrust restraints relying on welded bars or rings.
   b. Weld procedure qualifications.
   c. Load proof-testing report of prototype restraint for any size coupling.
2. Basket Strainer:
   a. Manufacturer's written/printed installation instructions.
   b. Manufacturer's Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers' Field Services.

C. Operation and Maintenance Data as specified in Section 01 78 23, Operation and Maintenance Data.

1.03 EXTRA MATERIALS

A. Furnish, tag, and box for shipment and storage the following spare parts and special tools for basket strainer:

Item	Quantity
[A: Basket]	**[B: One] [C:]** for each strainer
[A: Disc seals]	**[B: One] [C:]** for each strainer
[A:]	**[B:]**
Special tools required to maintain or dismantle	**[A: One] [B:]** complete set

B. [**A: Delivery: __]**

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PART 2 PRODUCTS

2.01 GENERAL

A. Provide required piping specialty items, whether shown or not shown on Drawings, as required by applicable codes and standard industry practice.

B. Rubber ring joints, mechanical joints, flexible couplings, and proprietary restrained ductile iron pipe joints are considered flexible joints; welded, screwed, and flanged pipe joints are not considered flexible.

C. Components and Materials in Contact with Water for Human Consumption: Comply with the requirements of the Safe Drinking Water Act and other applicable federal, state, and local requirements. Provide certification by manufacturer or an accredited certification organization recognized by the Authority Having Jurisdiction that components and materials comply with the maximum lead content standard in accordance with NSF/ANSI 61 and NSF/ANSI 372.

1. Use or reuse of components and materials without a traceable certification is prohibited.

2.02 CONNECTORS

A. Teflon Bellows Connector:

1. Type: Two convolutions, unless otherwise shown, with metal reinforcing bands.
2. Flanges: Ductile iron, drilled 150 psi ASME B16.5 standard.
3. Working Pressure Rating: 140 psi, minimum, at 120 degrees F.
4. Thrust Restraint: Limit bolts to restrain force developed by specified test pressure.
5. Manufacturers and Products:
   a. Garlock; Style **[A: 214] [B:]**.
   b. Resistoflex; No. **[C: R6904] [D:]**.
   c. Unisource Manufacturing, Inc.; Style 112.
   d. Proco Products, Inc.; Series 442.

B. Elastomer Bellows Connector:

1. Type: Fabricated spool, with single filled arch.
2. Materials: Nitrile tube and wrap-applied neoprene cover.
3. End Connections: Flanged, drilled 125-pound ASME B16.1 standard, with full elastomer face and steel retaining rings.
4. Working Pressure Rating: 140 psig, minimum, at 180 degrees F for sizes 12 inches and smaller.

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5. Thrust Restraint: Control rods to limit travel of elongation and compression.
6. Manufacturers and Products:
    a. Goodall Rubber Co.; Specification **[A: E-1462] [B:]**.
    b. Garlock; Style **[C: 204] [D:]**.
    c. Unisource Manufacturing, Inc.; Style 1501.
    d. Proco Products, Inc.; Series 220.

C. Metal Bellows Connector:

1. Type: Single-ply, annular corrugated metal bellows with limit rods. Circumferential convolution welds not permitted.
2. Material: Type 316 stainless steel.
3. End Connections: ANSI 150-pound carbon steel flanges.
4. Minimum Design Working Pressure: 50 psig at 300 degrees F.
5. Length: Minimum of four convolutions and minimum manufacturer recommendation for vibration isolation.
6. Manufacturers and Products:
    a. U.S. Bellows, Inc.; Universal Tied Expansion Joint.
    b. Metraflex; Model MN.
    c. Senior Flexonics Pathway, Inc.; Expansion Joints.

D. Flexible Metal Hose Connector:

1. Type: Close pitch, annular corrugated with single braided jacket.
2. Material: Bronze.
3. End Connections: Female copper solder joint.
4. Minimum Burst Pressure: 500 psig at 70 degrees F.
5. Length: Minimum manufacturer recommendation for vibration isolation.
6. Manufacturers:
    a. U.S. Hose Corp.; Series 300.
    b. Anamet Industrial, Inc.
    c. Unisource Manufacturing, Inc.
    d. Proco Products, Inc.

E. Closure Collar Concrete: As specified in Section **[A: 03 30 00, Cast-in-Place] [B: 03 30 01, Reinforced]** Concrete.

F. Quick Connect Couplings for Chemical Services:

1. Type: Twin cam arm actuated, male and female, locking, for chemical loading and transfer.
2. Materials: Glass-filled polypropylene or PVDF with EPDM, Viton-A or Teflon gaskets as recommended for the service by manufacturer.

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3. End Connections: NPT threaded or flanged to match piping connections. Hose shank for chemical installations.
4. Plugs and Caps: Female dust cap for each male end; male dust plug for each female end.
5. Pressure Rating: 125 psi, minimum, at 70 degrees F.
6. Manufacturers and Products:
    a. OPW; Kamlock.
    b. Ryan Herco; 1300 Series.

2.03 COUPLINGS

A. General:

1. Coupling linings for use in potable water systems shall be in conformance with NSF/ANSI 61.
2. Couplings shall be rated for working pressure not less than indicated in Piping Schedule for the service and not less than 150 psi.
3. Couplings shall be lined and coated with fusion-bonded epoxy in accordance with AWWA C213 or lined and coated with liquid epoxy in accordance with AWWA C210.
4. Unless thrust restraint is provided by other means, couplings shall be harnessed in accordance with requirements of AWWA Manual M11 or as shown on Drawings.
5. Sleeve type couplings shall conform to AWWA C219 and shall be hydraulically expanded beyond minimum yield for accurate sizing and proofing of tensile strength.

B. Flexible Sleeve Type Coupling:

1. Manufacturers and Products:
    a. Steel Pipe:
        1) Dresser Piping Specialties; Style **[A: 38] [B:]**.
        2) Smith-Blair, Inc.; Style **[C: 411] [D:]**.
    b. Ductile Iron Pipe:
        1) Dresser Piping Specialties; Style **[E: 253] [F:]**.
        2) Smith-Blair, Inc.; Style **[G: 441] [H:]**.

C. Transition Coupling for Steel Pipe:

1. Manufacturers and Products:
    a. Dresser Piping Specialties; Style **[A 162] [B:]**.
    b. Smith-Blair, Inc.; Style **[C: 413] [D:]**.

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D. Flanged Coupling Adapter:

1. Anchor studs where required for thrust restraint.
2. Manufacturers and Products:
   a. Steel Pipe:
      1) Dresser Piping Specialties; Style **[A: 128] [B:]**.
      2) Smith-Blair, Inc.; Style **[C: 913] [D:]**.
   b. Ductile Iron Pipe:
      1) Dresser Piping Specialties; Style **[E: 128] [F:]**.
      2) Smith-Blair, Inc.; Style **[G: 912] [H:]**.

E. Restrained Flange Adapter:

1. Pressure Rating:
   a. Minimum Working Pressure Rating: Not less than 150 psi.
   b. Safety Factor: Not less than two times working pressure and shall be supported by manufacturer's proof testing.
2. Thrust Restraint:
   a. Provide hardened steel wedges that bear against and engage outer pipe surface, and allow articulation of pipe joint after assembly while wedges remain in their original setting position on pipe surface.
   b. Products employing set screws that bear directly on pipe will not be acceptable.
3. Manufacturer and Product: EBAA Iron Sales Co.; Mega-Flange.

F. Restrained Dismantling Joints:

1. Pressure Rating:
   a. Minimum working pressure rating shall not be less than rating of the connecting flange.
   b. Proof testing shall conform to requirements of AWWA C219 for bolted couplings.
2. Manufacturers and Products:
   a. Dresser Piping Specialties; Style 131.
   b. Smith Blair, Inc.; Model 975.

G. Exposed Metallic Piping Plain End Couplings:

1. Plain end pipe couplings shall be self-restrained against hydrostatic thrust forces equal to not less than two times the working pressure rating of the coupling. Couplings shall accommodate 4 degrees angular deflection at the time of installation and subsequent to pressurization.
2. Casing, bolts, and nuts shall be Type 304 or Type 316 stainless steel. The sealing sleeve shall be EPDM or NBR elastomer as best suited for the fluid service.

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3. Couplings manufacturer and products shall be Straub Couplings, Grip-L or Metal Grip, or equal.

2.04 EXPANSION JOINTS

A. Elastomer Bellows:

1. Type: Reinforced molded wide arch.
2. End Connections: Flanged, drilled 125-pound ASME B16.1 standard, with split galvanized steel retaining rings.
3. Washers: Over retaining rings to help provide leak-proof joint under test pressure.
4. Thrust Protection: Control rods to protect the bellows from overextension.
5. Bellows Arch Lining: Buna-N, nitrile, or butyl.
6. Rated Temperature: **[A: 250] [B:]** degrees F.
7. Rated Deflection and Pressure:
   a. Lateral Deflection: 3/4 inch, minimum.
   b. Burst Pressure: Four times the working pressure.
   c. Compression deflection and minimum working pressure as follows:

Size (inch)	**Deflection (inch)**	**Pressure (psig)**
2-1/2 to 12	1.06	150
14	1.65	130
16 to 20	1.65	110

8. Manufacturers and Products:
   a. General Rubber Corp.; Style **[C: 1015 Maxijoint] [D:]**.
   b. Mercer; Flexmore Style **[E: 450] [F:]**.
   c. Goodall Rubber Co.; Specification **[G: E-711] [H:]**.
   d. Unisource Manufacturing, Inc.; Series 1500.
   e. Proco Products, Inc.; Series 251.

B. Teflon Bellows:

1. Type: Three convolutions, with metal reinforcing bands.
2. Flanges: Ductile iron, drilled 150 psi ASME B16.5 standard.
3. Working Pressure Rating: 100 psig, minimum, at 120 degrees F.
4. Thrust Restraint: Limit bolts to restrain force developed by specified test pressure.
5. Manufacturers and Products:
   a. Garlock; Style **[A: 215] [B:]**.
   b. Resistoflex; No. **[C: R6905] [D:]**.

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c. Unisource Manufacturing, Inc.; Style 113.
d. Proco Products, Inc.; Series 443.

C. Metal Bellows:

1. Type: Single-ply, annular corrugated metal bellows with limit rods. Circumferential convolution welds not permitted.
2. Material: Type 316 stainless steel.
3. End Connections: ASME 150-pound carbon steel flanges.
4. Minimum Design Working Pressure: 50 psig at 300 degrees F.
5. Length: Minimum of eight convolutions and minimum axial compression of 3/4 inches.
6. Manufacturers and Products:
   a. U.S. Bellows, Inc.; Universal Tied expansion joint.
   b. Metraflex, Model MN.
   c. Senior Flexonics Pathway, Inc.; Expansion Joints.

D. Copper Pipe Expansion Compensator:

1. Material: Stainless steel bellows with female copper solder joint ends.
2. Working Pressure Rating: 175 psig, minimum.
3. Accessories: Anti-torque device to protect bellows.
4. Manufacturers and Products:
   a. Senior Flexonics; Model **[A: HB] [B:]**.
   b. Hyspan; Model **[C: 8510] [D:]**.
   c. Unisource Manufacturing, Inc.; Style EC-FFS.

E. Galvanized and Black Steel Pipe Expansion Compensator:

1. Material: **[A: Carbon steel with stainless steel bellows.] [B: All stainless steel.]**
2. Working Pressure Rating: 175 psig, minimum.
3. Accessories: Anti-torque device to protect bellows.
4. Manufacturers and Products:
   a. Senior Flexonics; Model **[C: H] [D:]**.
   b. Hyspan; Model **[E: 8503] [F:]**.
   c. Unisource Manufacturing, Inc.; Style EC-MMT.

F. Flexible Metal Hose:

1. Type: Close pitch, annular corrugated with single braided jacket.
2. Material: Stainless steel, ASTM A276, Type 321.
3. End Connections:
   a. 3 Inches and Larger: Shop fabricated flanged ends to match mating flanges.
   b. 2-1/2 Inches and Smaller: Screwed ends with one union end.

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4. Minimum Burst Pressure: 600 psig at 70 degrees F for 12 inches and smaller.
5. Length: Provide hose live-length equal to lengths shown on Drawings.
6. Manufacturer:
    a. U.S. Hose Corp.; Series **[A: 401M] [B:]**.
    b. Anamet Industrial, Inc.; **[C: BWC21-1] [D:]**.

2.05 FLEXIBLE EXPANSION JOINTS

A. Design:

1. Ball and socket type for earth settlement compensation.
2. Joints shall be double ball assemblies rated for 15-degree minimum deflection and not less than 4 inches offset from centerline of connecting piping.
3. Assembly shall accommodate up to 4 inches of expansion in length.
4. Ductile iron conforming to AWWA C153/A21.53.
5. Rated for 350 psi.
6. Components shall be lined and coated by manufacturer with fusion-bonded epoxy on all surfaces not bearing gaskets.
7. End Connections: Flanged or mechanical joint as shown and as required by connecting pipe and fittings.
8. Joint connecting to mechanical joint shall be thrust restrained.
9. Bonding:
    a. Manufacturer shall factory install thermite welded joint bonds for assembled expansion joint.
    b. Provide 24-inch bond wires for field bonds to adjacent metallic piping.
    c. Bond wires shall be 2 AWG with two 12-inch-long THHN insulated 12 AWG wire pigtails.

B. Manufacturer and Product: EBAA Iron Sales Co.; Flex-Tend.

2.06 SEAL WATER HOSE

A. Product as specified for water hose, except 3/8 inch with male NPT ends, in 2-foot lengths.

2.07 SERVICE SADDLES

A. Double-Strap Iron:

1. Pressure Rating: Capable of withstanding 150 psi internal pressure without leakage or over stressing.
2. Run Diameter: Compatible with outside diameter of pipe on which saddle is installed.

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3. Taps: Iron pipe threads.
4. Materials:
    a. Body: Malleable or ductile iron.
    b. Straps: Galvanized steel.
    c. Hex Nuts and Washers: Steel.
    d. Seal: Rubber.
5. Manufacturers and Products:
    a. Smith-Blair; Series **[A: 313 or 366] [B:]**.
    b. Dresser; Style **[C: 91] [D:]**.

B. Nylon-Coated Iron:

1. Pressure Rating: Capable of withstanding 150 psi internal pressure without leakage or over stressing.
2. Run Diameter: Compatible with outside diameter of pipe on which saddle is installed.
3. Materials:
    a. Body: Nylon-coated iron.
    b. Seal: Buna-N.
    c. Clamps and Nuts: Stainless steel.
4. Manufacturer: Smith-Blair; Style **[A: 315 or 317] [B:]**.

2.08 OUTLET/TAPPING SADDLES

A. Materials:

1. Straps: Alloy steel with 3/4-inch threaded ends.
2. Seal: O-Ring SBR rubber gasket.
3. Compatible with ductile iron pipe.

B. Connection: **[A: AWWA C110/A21.10 flange.] [B: Mechanical joint outlet.] [C: As shown.]**

C. Pressure Rating: Capable of withstanding 250 psi internal pressure without leakage over stressing.

D. Manufacturer and Product: American Ductile Iron; Outlet/Tapping Saddle.

2.09 PIPE SLEEVES

A. Steel Pipe Sleeve:

1. Minimum Thickness: 3/16 inch.
2. Seep Ring:
    a. Center steel flange for water stoppage on sleeves in exterior or water-bearing walls, 3/16-inch minimum thickness.

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b. Outside Diameter: Unless otherwise shown, 3 inches greater than pipe sleeve outside diameter.
c. Continuously fillet weld on each side all around.

3. Factory Finish:
   a. Galvanizing:
      1) Hot-dip applied, meeting requirements of ASTM A153/A153M.
      2) Electroplated zinc or cadmium plating is unacceptable.
   b. Shop Lining and Coating: Factory prepare, prime, and finish coat in accordance with Section 09 90 00, Painting and Coating.

B. Molded Polyethylene Pipe Sleeve:

1. Molded HDPE with integral water stop ring not less than 3 inches larger than sleeve.
2. Provided with end caps for support during concrete placement.
3. Manufacturer and Product: Century-Line, Model CS sleeves as manufactured by PSI-Thunderline/Link-Seal.

C. Insulated and Encased Pipe Sleeve:

1. Manufacturer and Product: Pipe Shields, Inc.; Models WFB, WFB-CS and -CW Series, as applicable.

D. Modular Mechanical Seal:

1. Type: Interconnected synthetic rubber links shaped and sized to continuously fill annular space between pipe and wall sleeve opening.
2. Fabrication:
   a. Assemble interconnected rubber links with ASTM A276, Type 316 stainless steel bolts and nuts.
   b. Pressure plates shall be reinforced nylon polymer.
3. Size: According to manufacturer's instructions for size of pipes shown to provide a watertight seal between pipe and wall sleeve opening **[A: , and to withstand a hydrostatic head of 40 feet of water]**.
4. Manufacturer: Thunderline Corp., Link-Seal Division.

2.10 SLAB, FLOOR, WALL AND ROOF PENETRATIONS

A. Ductile Iron Wall Pipe:

1. Diameter, Lining, and Ends: Same as connecting ductile iron pipe.
2. Thickness: Equal to or greater than remainder of pipe in line.
3. Fittings: In accordance with applicable Pipe Data Sheet.

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4. Thrust Collars:
    a. Rated for thrust load developed at 250 psi.
    b. Safety Factor: 2, minimum.
    c. Material and Construction: Ductile iron or cast iron, cast integral with wall pipe wherever possible, or thrust rated, welded attachment to wall pipe.
5. Manufacturers:
    a. American Cast Iron Pipe Co.
    b. U.S. Pipe and Foundry Co.

B. Steel or Stainless Steel Wall Pipe:

1. Same material and thickness as connecting pipe, except 1/4-inch minimum thickness.
2. Lining: Same as connecting pipe.
3. Thrust Collar:
    a. Outside Diameter: Unless otherwise shown, 3 inches greater than outside diameter of wall pipe.
    b. Continuously fillet welded on each side all around.

2.11 CHEMICAL INJECTOR SYSTEM

A. Chemical Injectors:

1. Type, size, quantity, and materials as shown on Drawings and Standard Details.
2. Manufacturer: SAF-T-FLO.

B. Support System:

1. Stainless steel Unistrut or FRP Aickenstrut.
2. Materials compatible with chemical service and subject to Engineer approval.

C. Connectors: Stainless steel service saddle or weld-o-let, as shown on Drawings.

2.12 MISCELLANEOUS SPECIALTIES

A. Strainers, Water Service, 2 Inches and Smaller:

1. Type: Bronze body, Y-pattern, 200 psi nonshock rated, with screwed gasketed bronze cap.
2. Screen: Heavy-gauge Type 304 stainless steel or monel, 20-mesh.
3. Manufacturers and Products:
    a. Armstrong International; Inc.; Model F.
    b. Mueller Steam Specialty; Model 351M.

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B. Strainers, Water Service, 2-1/2 Inches and Larger:

1. Type: Cast iron or ductile iron body, Y-pattern, 175 psi nonshock rated, with flanged gasketed iron cap.
2. Screen: Heavy-gauge Type 316 stainless steel, 0.045-inch perforations.
3. Manufacturer and Product: Armstrong International, Inc.; Model A7FL 125.

C. Strainers, Plastic Piping Systems, 4 Inches and Smaller:

1. Type: Y-pattern PVC body, 150 psi nonshock rated, with screwed PVC cap and Viton seals.
2. End Connections: Screwed or solvent weld, 2 inches and smaller. Class 150 ANSI flanged, 2-1/2 inches and larger.
3. Screen: Heavy-gauge PVC, 1/32-inch mesh, minimum 2 to 1 screen area to pipe size ratio.
4. Manufacturer: Hayward.

D. Basket Strainer:

1. Service Conditions:
   a. Material Handled: **[A: Plant final effluent (No. 3 water)] [B:]**.
   b. Temperature of Material Handled: **[C:]** degrees F, minimum to **[D:]** degrees F, maximum.
   c. Specific Gravity of Material Handled: **[E:]**.
   d. pH Range of Material Handled: **[F:]**.
   e. Range of Total Suspended Solids: **[G:]** mg/L.
2. Strainer Capacity: **[H:]** gpm, maximum pressure drop shall not exceed **[I:]** psi at **[J:]** gpm.
3. Screen: Capable of removing material larger than **[K: 0.01 inch (250 microns)] [L:]** in diameter.
4. Strainer: Single chamber design of **[M: cast iron] [N: fabricated steel] [O: stainless steel]** construction with a **[P: bolted] [Q: quick opening]** cover.
5. Process Connections: **[R: 1]**-inch flanges faced and drilled **[S: 125] [T: 150]** pound ASME B16.5.
6. Strainer: Double chamber design of **[U: fabricated steel] [V: stainless steel]** construction.
7. Permit one basket strainer to be removed for cleaning while other basket is in operation.
8. Inlet and Outlet Valves: **[W: Three-way globe type] [X: Lever operated swing type valve disc]** with neoprene disc seals.
9. Baskets: **[Y: Type 304 stainless steel.] [Z: Type 316 stainless steel.] [A: Monel.]**

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10. Wearing parts shall be replaceable without removing strainer from line.
11. Factory Finishing:
    a. Prepare, prime, and finish coat in accordance with Section 09 90 00, Painting and Coating.
    b. **[B: Furnish manufacturer's standard [C: baked] enamel finish, color as selected.] [D: Match color as specified in pipe schedule.]**
12. Manufacturer: S.P. Kinney Engineers, Inc.

E. Water Hose:

1. Furnish **[A:]** 50-foot lengths of 1-inch and **[B:]** 50-foot lengths of 1-1/2-inch rubber hose. EPDM black cover and EPDM tube, reinforced with two textile braids. Provide each length with brass male and female NST hose thread couplings to fit hose nozzle and hose valve.
2. Rated minimum working pressure of 200 psi.
3. Manufacturers:
    a. Goodyear.
    b. Boston.

F. Hose Nozzles:

1. Furnish **[A:]** 1-inch and **[B:]** 1-1/2-inch cast brass, satin finish, nozzles with adjustable fog, straight-stream, and shut-off feature and rubber bumper. Provide nozzles with female NST hose thread.
2. Manufacturers:
    a. Croker.
    b. Elkhart.

G. Pump Seal Water Sight Flow Indicators:

1. Bronze body, 3/8-inch, horizontal, ball action with tempered glass.
2. Rated 125 psi with NPT screwed ends.
3. Operate with a minimum flow of 0.25 gpm.
4. Manufacturers and Products:
    a. Eugene Ernst Co.; Series E-57-4.
    b. Jacoby Tarbox Co.

H. Orifice Plate with Plate Holder: **[A: .]**

PART 3 EXECUTION

3.01 GENERAL

A. Provide accessibility to piping specialties for control and maintenance.

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3.02 PIPING FLEXIBILITY PROVISIONS

A. General:

1. Thrust restraint shall be provided as specified in Section 40 27 00, Process Piping—General.
2. Install flexible couplings to facilitate piping installation, in accordance with approved shop drawings.

B. Flexible Joints at Concrete Backfill or Encasement: Install within 18 inches or one-half pipe diameter, whichever is less, from the termination of any concrete backfill or concrete encasement.

C. Flexible Joints at Concrete Structures:

1. Install 18 inches or less from face of structures; joint may be flush with face.
2. **[A: Install a second flexible joint, whether or not shown.]**
   a. **[B: Pipe Diameter 18 Inches and Smaller: Within 18 inches of first joint.]**
   b. **[C: Pipe Diameter Larger than 18 Inches: Within two to three pipe diameter of first joint.]**

D. **[A: Flexible expansion joints shall be provided to compensate for earth settlement at buried piping connections to structure wall pipes. Wrap complete joint assembly in a double layer of polyethylene encasement, as specified in Section 40 27 00, Process Piping—General.]**

3.03 PIPING TRANSITION

A. Applications:

1. Provide complete closure assembly where pipes meet other pipes or structures.
2. Pressure Pipeline Closures: Plain end pieces with double flexible couplings, unless otherwise shown.
3. Restrained Joint Pipe Closures: Install with thrust tie-rod assemblies as shown **[A: or in accordance with NFPA 24]**.
4. Gravity Pipe Closures: As specified for pressure pipelines, or concrete closures.
5. Concrete Closures: Use to make connections between dissimilar pipe where standard rubber gasketed joints or flexible couplings are impractical, as approved.
6. Elastomer sleeves bonded to pipe ends are not acceptable.

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B. Installation:

1. Flexible Transition Couplings: Install in accordance with coupling manufacturer's instructions to connect dissimilar pipe and pipes with a small difference in outside diameter.
2. Concrete Closures:
   a. Locate away from structures so there are at least two flexible joints between closure and pipe entering structure.
   b. Clean pipe surface before placing closure collars.
   c. Wet nonmetallic pipe thoroughly prior to pouring collars.
   d. Prevent concrete from entering pipe.
   e. Extend collar a minimum of 12 inches on each side of joint with minimum thickness of 6 inches around outside diameter of pipe.
   f. Make entire collar in one placement.
   g. After concrete has reached initial set, cure by covering with well-moistened earth.

3.04 PIPING EXPANSION

A. Piping Installation: Allow for thermal expansion due to differences between installation and operating temperatures.

B. Expansion Joints:

1. Grooved Joint and Flanged Piping Systems: Elastomer bellows expansion joint.
2. Nonmetallic Pipe: Teflon bellows expansion joint.
3. Screwed and Soldered Piping Systems: Copper or galvanized and black steel pipe expansion compensator, as applicable.
4. Air and Water Service above 120 Degrees F: Metal bellows expansion joint.
5. Pipe Run Offset: Flexible metal hose.

C. Weld-End Metal Bellows Installation:

1. Field Weld: Stainless steel bellows beveled ends joined to ALP carbon steel piping in accordance with approved welding procedures.
2. Lining:
   a. System No. 4, high-temperature epoxy, in accordance with Section 09 90 00, Painting and Coating.
   b. Field apply lining to protect bellows and piping from rust at welded joint.
   c. Line both ends inside bellows, entire length of extension stub end, and from weld joint to a distance of 1 foot inside length of the carbon steel pipe.

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3. Coating:
    a. System No. 4, high-temperature epoxy, in accordance with Section 09 90 00, Painting and Coating.
    b. Field apply coating to protect bellows and piping from weather and rust at welded joint.
    c. Coat both ends outside bellows, entire length of extension stub end, and from weld joint to a distance of 1 foot outside length of the carbon steel pipe.

D. Anchors **[A: and Anchor Walls]**: Install as specified in Section 40 05 15, Piping Support Systems, to withstand expansion joint thrust loads and to direct and control thermal expansion.

3.05 SERVICE SADDLES

A. Ferrous Metal Piping (except stainless steel): Double-strap iron.

B. Plastic Piping: Nylon-coated iron.

3.06 OUTLET/TAPPING SADDLE

A. Install in accordance with manufacturer's written instructions.

3.07 COUPLINGS

A. General:

1. Install in accordance with manufacturer's written instructions.
2. Before coupling, clean pipe holdback area of oil, scale, rust, and dirt.
3. **[A: Remove pipe coating if necessary to present smooth surface.] [B: Do not remove pipe coating. If damaged, repair before joint is made.]**
4. Application:
    a. Metallic Piping Systems: Flexible couplings, transition couplings, and flanged coupling adapters.
    b. Concrete Encased Couplings: Flexible coupling.

3.08 FLEXIBLE PIPE CONNECTIONS TO EQUIPMENT

A. Install to prevent piping from being supported by equipment, for vibration isolation, and where shown.

B. Product Applications Unless Shown Otherwise:

1. Nonmetallic Piping: Teflon bellows connector.
2. Copper Piping: Flexible metal hose connector.

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3. Compressor and Blower Discharge: Metal bellows connector.
4. All Other Piping: Elastomer bellows connector.

C. Limit Bolts and Control Rods: Tighten snug prior to applying pressure to system.

3.09 PIPE SLEEVES

A. Application:

1. As specified in Section 40 27 00, Process Piping—General.
2. Above Grade in Nonsubmerged Areas: Hot-dip galvanized after fabrication.
3. Below Grade or in Submerged or Damp Environments: Shop-lined and coated.
4. Alternatively, Molded Polyethylene Pipe Sleeve as specified may be applied.

B. Installation:

1. Support noninsulating type securely in formwork to prevent contact with reinforcing steel and tie-wires.
2. Caulk joint with specified sealant in non-submerged applications and seal below grade and submerged applications with wall penetration seal.

3.10 SLAB, FLOOR, WALL AND ROOF PENETRATIONS

A. Applications:

1. Watertight and Below Ground Penetrations:
   a. Wall pipes with thrust collars.
   b. Provide taps for stud bolts in flanges to be set flush with wall face.
2. Nonwatertight Penetrations: Pipe sleeves with seep ring.
3. Existing Walls: Rotary drilled holes.
4. Fire-Rated or Smoke-Rated Walls, Floors or Ceilings: Insulated and encased pipe sleeves.

B. Wall Pipe Installation:

1. Isolate embedded metallic piping from concrete reinforcement **[A: using coated pipe penetrations as specified in Section 09 90 00, Painting and Coating]**.
2. Support wall pipes securely by formwork to prevent contact with reinforcing steel and tie-wires.

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3.11 CHEMICAL INJECTOR SYSTEM

A. Install in accordance with manufacturer's instructions.

3.12 MISCELLANEOUS SPECIALTIES

A. Basket Strainers:

1. Install in accordance with manufacturer's instructions.
2. Field Quality Control:
   a. Conduct test on each basket strainer.
   b. **[A: Test valves shall be tested for proper seating, travel, and operation.]**
3. Manufacturer's Services: Provide manufacturer's representative at Site **[A: in accordance with Section 01 43 33, Manufacturers' Field Services, and Section 01 91 14, Equipment Testing and Facility Startup]** for installation assistance, inspection and certification of proper installation, equipment testing, startup assistance, and training of **[B: Owner's] [C:]** personnel for specified component, subsystem, equipment, or system.

END OF SECTION

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SECTION 40 27 02
PROCESS VALVES AND OPERATORS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Gas Association (AGA): 3, Orifice Metering of Natural Gas and Other Related Hydrocarbon Fluids.
2. American National Standards Institute (ANSI): Z21.15, Manually Operated Gas Valves for Appliances, Appliance Connector Valves and Hose End Valves.
3. American Society of Mechanical Engineers (ASME):
   a. B16.1, Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.
   b. B16.44, Manually Operated Metallic Gas Valves for Use in Above Ground Piping Systems up to 5 psi.
4. American Society of Sanitary Engineers (ASSE): 1011, Performance Requirements for Hose Connection Vacuum Breakers.
5. American Water Works Association (AWWA):
   a. C111/A21.11, Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
   b. C500, Metal-Seated Gate Valves for Water Supply Service.
   c. C504, Rubber-Seated Butterfly Valves, 3 In. (75 mm) Through 72 In. (1,800 mm).
   d. C508, Swing-Check Valves for Waterworks Service, 2-In. Through 24-In. (50-mm Through 600-mm) NPS.
   e. C509, Resilient-Seated Gate Valves for Water Supply Service.
   f. C510, Double Check Valve Backflow Prevention Assembly.
   g. C511, Reduced-Pressure Principle Backflow Prevention Assembly.
   h. C512, Air-Release, Air/Vacuum, and Combination Air Valves for Waterworks Service.
   i. C515, Reduced-Wall, Resilient-Seated Gate Valves for Water Supply Service.
   j. C541, Hydraulic and Pneumatic Cylinder and Vane-Type Actuators for Valves and Slide Gates.
   k. C542, Electric Motor Actuators for Valves and Slide Gates.
   l. C550, Protective Interior Coatings for Valves and Hydrants.
   m. C606, Grooved and Shouldered Joints.
   n. C800, Underground Service Line Valves and Fittings.

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6. ASTM International (ASTM):
    a. A276, Standard Specification for Stainless Steel Bars and Shapes.
    b. A351/A351M, Standard Specification for Castings, Austenitic, for Pressure-Containing Parts.
    c. A380, Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.
    d. A564/A564M, Standard Specification for Hot-Rolled and Cold-Finished Age-Hardening Stainless Steel Bars and Shapes.
    e. B61, Standard Specification for Steam or Valve Bronze Castings.
    f. B62, Standard Specification for Composition Bronze or Ounce Metal Castings.
    g. B98/B98M, Standard Specification for Copper-Silicon Alloy Rod, Bar, and Shapes.
    h. B127, Standard Specification for Nickel-Copper Alloy (UNS N04400) Plate, Sheet, and Strip.
    i. B139/B139, Standard Specification for Phosphor Bronze Rod, Bar and Shapes.
    j. B164, Standard Specification for Nickel-Copper Alloy Rod, Bar, and Wire.
    k. B194, Standard Specification for Copper-Beryllium Alloy Plate, Sheet, Strip, and Rolled Bar.
    l. B584, Standard Specification for Copper Alloy Sand Castings for General Applications.
    m. D429, Standard Test Methods for Rubber Property-Adhesion to Rigid Substrates.
    n. D1784, Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds.
7. Canadian Standards Association, Inc. (CSA): 9.1, Manually Operated Gas Valves for Appliances, Appliance Connector Valves and Hose End Valves.
8. Chlorine Institute (CI): Pamphlet 6, Piping Systems for Dry Chlorine.
9. FM Global (FM).
10. Food and Drug Administration (FDA).
11. International Association of Plumbing and Mechanical Officials (IAPMO).
12. Manufacturers Standardization Society (MSS):
    a. SP-80, Bronze Gate, Globe, Angle, and Check Valves.
    b. SP-81, Stainless Steel, Bonnetless, Flanged Knife Gate Valves.
    c. SP-85, Gray Iron Globe and Angle Valves, Flanged and Threaded Ends.
    d. SP-88, Diaphragm Valves.
    e. SP-110, Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends.
13. National Electrical Manufacturers Association (NEMA): 250, Enclosures for Electrical Equipment (1000 Volts Maximum).

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14. NSF International (NSF):
    a. NSF/ANSI 61, Drinking Water System Components - Health Effects.
    b. NSF/ANSI 372, Drinking Water System Components - Lead Content.
15. Underwriters Laboratories (UL).
16. USC Foundation for Cross-Connection Control and Hydraulic Research.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
    a. Product data sheets for each make and model. Indicate valve Type Number, applicable Tag Number, and facility name/number or service where used.
    b. Complete catalog information, descriptive literature, specifications, and identification of materials of construction.
    c. Certification for compliance to NSF/ANSI 61 for valves used for drinking water service.
    d. Power and control wiring diagrams, including terminals and numbers.
    e. For each power actuator provided, manufacturer's standard data sheet, with application specific features and options clearly identified.
    f. Sizing calculations for open-close/throttle and modulating valves.
    g. Anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.

B. Informational Submittals:

1. Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements, for:
    a. Electric actuators; full compliance with AWWA C542.
    b. Butterfly valves; full compliance with AWWA C504.
3. Component and attachment testing seismic certificate of compliance as required by Section 01 45 33, Special Inspection, Observation and Testing.
4. Tests and inspection data.
5. Operation and Maintenance Data as specified in Section 01 78 23, Operation and Maintenance Data.
6. Manufacturer's Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers' Field Services.

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PART 2 PRODUCTS

2.01 GENERAL

A. Valves to include operator, actuator, handwheel, chain wheel, extension stem, floor stand, operating nut, chain, wrench, and accessories to allow a complete operation from the intended operating level.

B. Valve to be suitable for intended service. Renewable parts not to be of a lower quality than specified.

C. Valve same size as adjoining pipe, unless otherwise called out on Drawings or in Supplements.

D. Valve ends to suit adjacent piping.

E. Resilient seated valves shall have no leakage (drip-tight) in either direction at valve rated design pressure. All other valves shall have no leakage (drip-tight) in either direction at valve rated design pressure, unless otherwise allowed for in this section or in stated valve standard.

F. Size operators and actuators to operate valve for full range of pressures and velocities.

G. Valve to open by turning counterclockwise, unless otherwise specified.

H. Factory mount operator, actuator, and accessories.

I. Components and Materials in Contact with Water for Human Consumption: Comply with the requirements of the Safe Drinking Water Act and other applicable federal, state, and local requirements. Provide certification by manufacturer or an accredited certification organization recognized by the Authority Having Jurisdiction that components and materials comply with the maximum lead content standard in accordance with NSF/ANSI 61 and NSF/ANSI 372.

1. Use or reuse of components and materials without a traceable certification is prohibited.

2.02 SCHEDULE

A. Additional requirements relative to this section are shown on Electric Motor Actuated Valve Schedule and Self-Regulated Valve Schedule located at the end of this section.

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2.03 MATERIALS

A. Bronze and brass valve components and accessories that have surfaces in contact with water to be alloys containing less than 16 percent zinc and 2 percent aluminum.

1. Approved alloys are of the following ASTM designations: B61, B62, B98/B98M (Alloy UNS No. C65100, C65500, or C66100), B139/B139M (Alloy UNS No. C51000), B584 (Alloy UNS No. C90300 or C94700), B164, B194, and B127.
2. Stainless steel Alloy 18-8 may be substituted for bronze.

B. Valve materials in contact with or intended for drinking water service to meet the following requirements:

1. Materials to comply with requirements of the Safe Drinking Water Act and other applicable federal, state, and local requirements.
2. Coatings materials to be formulated from materials deemed acceptable to NSF/ANSI 61.
3. Supply certification product is certified as suitable for contact with drinking water by an accredited certification organization in accordance with NSF/ANSI 61. Provide certification for each valve type used for drinking water service**.**

2.04 FACTORY FINISHING

A. General:

1. Interior coatings for valves and hydrants shall be in accordance with AWWA C550, unless otherwise specified.
2. Exterior coating for valves and hydrants shall be in accordance with Section 09 90 00, Painting and Coating.
3. Material in contact with potable water shall conform to NSF/ANSI 61.
4. Exposed safety isolation valves and lockout valves with handles, handwheels, or chain wheels shall be “safety yellow.”

B. Where epoxy lining and coating are specified, factory finishing shall be as follows:

1. In accordance with AWWA C550.
2. Either two-part liquid material or heat-activated (fusion) material except only heat-activated material if specified as “fusion” or “fusion bonded” epoxy.
3. Minimum 7-mil dry film thickness except where limited by valve operating tolerances.

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2.05 VALVES

A. Gate Valves:

1. General:
   a. AWWA gate valves to be in full compliance with stated AWWA standard and the following requirements:
      1) Provide 2-inch operating nut and handwheel for AWWA gate valves 12 inches and smaller.
      2) Provide totally enclosed spur or bevel gear operator with indicator for AWWA gate valves 14 inches and larger.
      3) Provide Affidavit of Compliance per the applicable AWWA standard for AWWA gate valves.
      4) Mark AWWA gate valves with manufacturer's name or mark, year of valve casting, valve size, and working water pressure.
      5) Repaired AWWA gate valves shall not be submitted or supplied.
      6) Supply AWWA gate valves with stainless steel bolting.
      7) AWWA C509 and AWWA C515 valves may be substituted for each other.
2. Type V100 Gate Valve 3 Inches and Smaller:
   a. All-bronze, screwed bonnet, packed gland, single solid wedge gate, nonrising stem, Class 125 rated 200 psi CWP, complies with MSS SP-80 Type 1.
   b. Manufacturers and Products:
      1) Crane; Figure 438, NPT threaded ends.
      2) Stockham; Figure B103, NPT threaded ends.
      3) Crane; Figure 1324, soldered ends.
      4) Stockham; Figure B104, soldered ends.
   c. All-bronze, screwed bonnet, packed gland, single solid wedge gate, rising stem, Class 125 rated 200 psi CWP, complies with MSS SP-80 Type 2.
   d. Manufacturers and Products:
      1) Crane; Figure 428, NPT threaded ends.
      2) Stockham; Figure B-100, NPT threaded ends.
      3) Crane; Figure 1334, soldered ends.
      4) Stockham; Figure B-108, soldered ends.
3. Type V132 Resilient Seated Gate Valve 3 Inches to 12 Inches, for Buried Service:
   a. Iron body, resilient seat, bronze stem and stem nut, mechanical joint ends, nonrising stem, in accordance with AWWA C509, 2-inch operating nut, minimum design working water pressure 200 psig, full port, fusion epoxy coated inside and outside per AWWA C550, NSF/ANSI 61 certified.

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b. Manufacturers and Products:
   1) M&H Valve; AWWA C509.
   2) U.S. Pipe; A-USPO.

4. Type V134 Resilient Seated Ductile Iron Gate Valve 3 Inches to 36 Inches:
   a. Ductile iron body, resilient seat, bronze stem and stem nut, ASME B16.1 Class 125 flanged ends, nonrising stem, in accordance with AWWA C515, minimum design working water pressure 200 psig, full port, fusion epoxy coated inside and outside per AWWA C550, NSF/ANSI 61 certified.
   b. Manufacturers and Products:
      1) American Flow Control; Series 2500.
      2) M&H; Style 7000 and C515 Large RW Valves.
5. Type V150 Knife Gate Valve 24 Inches and Smaller:
   a. Bonnetless wafer body type, outside stem and yoke, rated for 150 psi cold water, ASME B16.1 flanged ends, self-cleaning, nonclogging, with round port, resilient neoprene seat, drip-tight shutoff.
   b. Wetted metal parts and stem, Type 316 stainless steel, yoke sleeve bronze, gate finish ground both sides with a sharp knife edge.
   c. Packing system leak-tight seal around gate, valve superstructure and yoke designed for full peripheral access to gland bolts when valve is equipped with manual or power actuator.
   d. In compliance with MSS SP-81.
   e. Manufacturers and Products:
      1) DeZurik; Series L.
      2) Rovang; Model L17.
      3) ITT Fabri-Valve; **[A: Figure 37L] [B: , with buttons] [C: Figure C67R]**.

B. Globe Valves:

1. Type V200 Globe Valve 3 Inches and Smaller:
   a. All-bronze, union bonnet, packed gland, inside screw, rising stem, TFE disc, Class 150 rated 150 psi SWP/300 psi CWP, complies with MSS SP-80 Type 2.
   b. Manufacturers and Products:
      1) Stockham; Figure B-22T, NPT threaded end.
      2) Crane Co.; Figure 7TF, NPT threaded end.
      3) Milwaukee; Model 1590T, soldered ends.
      4) NIBCO; Figure S-235-Y, soldered ends.
2. Type V201 Angle Pattern Valve 2 Inches and Smaller:
   a. All-bronze, NPT threaded ends, union bonnet, packed gland, inside screw, rising stem, TFE disc, Class 150 rated 150 psi SWP/300 psi CWP, complies with MSS SP-80 Type 2.

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b. Manufacturers and Products:
    1) Stockham; Figure B-222T.
    2) Crane Co.; Figure 17TF.

3. Type V202 Globe Valve 3 Inches and Smaller:
    a. All-bronze, union bonnet, packed gland, inside screw, rising stem, replaceable stainless steel tapered plug type disc and seat ring, Class 200 rated 200 psi SWP/400 psi CWP, complies with MSS SP-80 Type 3.
    b. Manufacturers and Products:
        1) Stockham; Figure B-62, NPT threaded end.
        2) Crane Co.; Figure 212P, NPT threaded end.
4. Type V204 Globe Valve 2 Inches and Smaller:
    a. All-bronze, NPT threaded ends, union bonnet, packed gland, inside screw, rising stem, replaceable stainless steel tapered plug type disc and seat ring, Class 300 rated 300 psi SWP/1,000 psi CWP, complies with MSS SP-80 Type 3.
    b. Manufacturers and Products:
        1) Crane; Figure 382P.
        2) Stockham; Figure B-74.
5. Type V205 Angle Pattern Valve 2 Inches and Smaller:
    a. All-bronze, NPT threaded ends, union bonnet, packed gland, inside screw, rising stem, replaceable stainless steel tapered plug type disc and seat ring, Class 300 rated 300 psi SWP/1,000 psi CWP, complies with MSS SP-80 Type 3.
    b. Manufacturers and Products:
        1) Stockham; Figure B-274.
        2) Crane; Figure 384P.
6. Type V208 Needle Disc Type Globe Valve 1/8 Inch to 3/4 Inch:
    a. All-bronze, threaded bonnet, packed gland, rising stem, bronze body and stem, Class 200 rated 200 psi SWP/400 psi CWP, complies with MSS SP-80.
    b. Manufacturers and Products:
        1) Crane Cat.; No. 88.
        2) Stockham; B-64.
7. Type V209 Needle Disc Type Globe Valve 1/8 Inch to 3/4 Inch:
    a. All-bronze, threaded bonnet, packed gland, rising stem, bronze body and stem, Class 200 rated 200 psi SWP/400 psi CWP, complies with MSS SP-80.
    b. Manufacturers and Products:
        1) Crane Cat.; No. 89.
        2) Stockham; B-264.
8. Type V210 Globe Valve 2 Inches to 10 Inches:
    a. Iron body, bronze mounted, flanged ends, bronze seat, outside screw and yoke, bolted bonnet, Class 125 rated 125 psi SWP/200 psi CWP, complies with MSS SP-85 Type 1.

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b. Manufacturers and Products:
   1) Stockham; G-512.
   2) Crane; Figure 351.

9. Type V234 Angle Type Hose Valve 1/2 Inch to 3/4 Inch:
   a. Bronze or manufacturer's standard brass, angle sillcock type body, threaded or solder inlet as applicable, pressure rating 125 psi cold water.
   b. Manufacturer and Product: Nibco; QTX Series.
10. Type V235 Angle Type Hose Valve 3/4 Inch:
   a. 3/4-inch NPT female inlet, 3/4-inch male hose thread outlet, heavy rough brass body rated 125 psi, lockshield bonnet, removable handle, atmospheric vacuum breaker conforming to ASSE 1011 and IAPMO code.
   b. Manufacturers and Products:
      1) Acorn; 8126, surface pipe mount valve, bent nose without flange.
      2) Acorn; 8121, surface mount through wall valve, bent nose with flange.
      3) Acorn; 8131, pipe and pedestal mounted valve located above 6 inches, straightnose.
      4) Acorn; 8136, pedestal mounted valve located lower than 6 inches, inverted nose.
11. Type V236 Globe Style Hose Valve 1 Inch to 3 Inches:
   a. All-bronze, NPT threaded ends, inside screw-type rising stem, TFE disc, **[A: cast brass male NPT by male NHT adapter with hexagonal center wrench nut,] [B: brass cap with chain,]** complies with MSS SP-80, rated 300 WOG.
   b. Manufacturers and Products:
      1) Stockham; Figure B-22T.
      2) Crane Co.; Cat. No. 7TF.
      3) Nibco; Figure T-235-Y.
12. Type V237 Angle Pattern Hose Valve 1 Inch to 2 Inches:
   a. All-bronze, NPT threaded ends, inside screw-type rising stem, TFE disc, **[A: cast brass male NPT by male NHT adapter with hexagonal center wrench nut,] [B: brass cap with chain,]** complies with MSS SP-80, rated 300 WOG.
   b. Manufacturers and Products:
      1) Stockham; Figure B-222T.
      2) Crane Co.; Cat. No. 17TF.
      3) Nibco; Figure T-335-Y.

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C. Ball Valves:

1. Type V300 Ball Valve 3 Inches and Smaller for General Water and Air Service:
   a. Two-piece, standard port, NPT threaded ends, bronze body and end piece, hard chrome-plated solid bronze or brass ball, RTFE seats and packing, blowout-proof stem, adjustable packing gland, zinc-coated steel hand lever operator with vinyl grip, rated 600-pound WOG, 150-pound SWP, complies with MSS SP-110. **[A: For steam service, provide stainless steel ball and stem.]**
   b. Manufacturers and Products:
      1) Threaded:
         a) Conbraco Apollo; 70-100.
         b) Nibco; T-580-70.
      2) Soldered:
         a) Conbraco Apollo; 70-200.
         b) Nibco; S-580-70.
2. Type V302 Actuator Ready Ball Valve 2 Inches and Smaller for General Water and Air Service:
   a. Two-piece, standard port, NPT threaded ends, bronze body and end piece, actuator mounting pad, Type 316 stainless steel ball and stem, vented ball, reinforced PTFE seats and seals, adjustable packing nut, blowout-proof stem, rated 600-pound WOG, 150-pound SWP, complies with MSS SP-110.
   b. Manufacturers and Products:
      1) Conbraco Apollo; 71-140.
      2) Milwaukee; 20BSOR-02.
3. Type V307 Stainless Steel Ball Valve 2 Inches and Smaller:
   a. Three-piece, full port, ASTM A276 GR 316 or ASTM A351/A351M GR CF8M stainless steel body and end pieces, Type 316 stainless steel ball, NPT threaded ends, reinforced PTFE seats, seals, and packing, adjustable packing gland, blowout-proof stainless steel stem, stainless steel lever operator with vinyl grip, rated 800 psig to 1,000 psig CWP, complies with MSS SP-110.
   b. Manufacturers and Products:
      1) Conbraco Apollo; 86R-100/86-500 Series.
      2) Nibco; T-595-S6-R-66-LL.
4. Type V320 Vee-Ball Valve 1 Inch to 16 Inches:
   a. ASME B16.1 Class 150-pound flanged ends, Type 317 stainless steel body, heat treated nickel- or hard chromium-plated Type 317 stainless steel ball, splined-type, 17-4 PH stainless steel shafts, reinforced PTFE flow-ring seal, reinforced PTFE with stainless steel or Hastalloy sleeve bearings, and PTFE V-ring packing. Valve to have 300:1 rangeability and equal percentage characteristic.

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b. Manufacturers and Products:
1) Fisher Controls: Design V150.
2) DeZurik: VPB V-Port Ball Valve.

5. Type V330 PVC Ball Valve 2 Inches and Smaller:
a. Rated 150 psi at 73 degrees F, with ASTM D1784, Type I, Grade 1 polyvinyl chloride body, ball, and stem, end entry, double union design, solvent-weld socket ends, elastomer seat, Viton or Teflon O-ring stem seals, to block flow in both directions. **[A: Provide pressure relief hole drilled on low pressure side of ball.]**
b. Manufacturers and Products:
1) Nibco; Chemtrol Tru-Bloc.
2) ASAHI/America; Type 21.
3) Spears; True Union.

6. Type V331 PVC Ball Valve 3 Inches and 4 Inches:
a. Rated 150 psi at 73 degrees F, with ASTM D1784 Type I, Grade 1 PVC full port body, Teflon seat, Viton O-ring stem, face and carrier seals, end entry design with dual union, solvent-weld socket ends, or single union ball valve with flanged ends drilled to ASME B16.1. **[A: Provide pressure relief hole drilled on low pressure side of ball.]**
b. Manufacturers and Products:
1) Nibco; Chemtrol Tru-Bloc.
2) ASAHI/America; Type 21.

7. Type V335 CPVC Ball Valve 2 Inches and Smaller:
a. Rated 150 psi at 100 degrees F, 80 psi at 140 degrees, with ASTM D1784, Type IV, Grade 1 chlorinated polyvinyl chloride (CPVC) body, ball, and stem, end entry, double union design, with solvent-weld socket ends or single union ball with flanged ends drilled to ASME B16.1, replaceable Teflon seat, Viton or Teflon O-ring stem seals, to block flow in both directions. **[A: Provide pressure relief hole drilled on low pressure side of ball.]**
b. Manufacturers and Products:
1) Nibco; Chemtrol Tru-Bloc.
2) ASAHI/America; Type 21.
3) Spears; True Union.

D. Plug Valves:

1. Type V400 Eccentric Plug Valve 2 Inches and Smaller:
a. Nonlubricated type rated 175 psig CWP, drip-tight shutoff with pressure from either direction, cast-iron body, threaded ends, lever operator, cast-iron plug with round or rectangular port, plug coated with Buna-N, stem bearing lubricated stainless steel or

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bronze, stem seal multiple V-rings, or U-cups with O-rings of nitrile rubber.

b. Manufacturers and Products:
   1) Pratt; Ballcentric.
   2) DeZurik; Style PEC.
   3) Milliken; Millcentric Series 603.

2. Type V405 Eccentric Plug Valve 3 Inches to 12 Inches:
   a. Nonlubricated type rated 175 psig CWP, drip-tight shutoff with pressure from either direction, cast-iron body, exposed service flanged ends per ASME B16.1 or grooved ends in accordance with AWWA C606 for rigid joints, buried service mechanical joint ends, unless otherwise shown.
   b. Plug cast iron with round or rectangular port of no less than 80 percent of connecting pipe area and coated with Buna-N, seats welded nickel, stem bearings lubricated stainless steel or bronze, stem seal multiple V-rings, or U-cups with O-rings of nitrile rubber, grit seals on both upper and lower bearings.
   c. For buried service, provide external epoxy coating.
   d. Operators:
      1) 3-Inch to 4-Inch Valves: Wrench lever manual.
      2) 6-Inch to 12-Inch Valves: Totally enclosed, geared, manual operator with handwheel, 2-inch nut or chain wheel. Size operator for 1.5 times maximum operating shutoff pressure differential for direct and reverse pressure, whichever is higher. For buried service, provide completely sealed operator filled with heavy lubricant and 2-inch nut.
   e. Manufacturers and Products:
      1) Pratt; Ballcentric.
      2) DeZurik; Style PEC.
      3) Milliken; Millcentric Series 600.

3. Type V410 Three-Way, Nonlubricated, Tapered Plug Valve 3 Inches to 16 Inches:
   a. Cast-iron body with Buna-N-coated plug, multiple V-rings or U-cups with O-ring seals, lubricated stainless steel bearings, and nickel- or epoxy-coated seat, rated 125 psi CWP minimum, flanged to ASME B16.1.
   b. Operator: **[A: Lever type.] [B: Gear type, totally enclosed and lubricated, with handwheel.]**
   c. Manufacturers and Products:
      1) DeZurik; Style PTW, Combination **[C:]**.
      2) Milliken; Millcentric Series 600, Style **[D:]**.

4. Type V462 Gauge Cock 1/8 Inch to 1/4 Inch:
   a. 1/4-inch bronze body, hexagon end pattern, tee head, male ends, rated 125-pound SWP.
   b. Manufacturer and Product: United Brass Works; Figure 973.

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5. Type V464 Corporation Stop 1/2 Inch to 2 Inches:
    a. AWWA C800 type, tapered threaded inlet, except when connecting to tapped fittings which require IPS tapered threads, outlet compression connection or IPS threads to suit connecting pipe, stops 1 inch and smaller rated 100 psi, larger stops rated 80 psi.
    b. Manufacturers and Products:
        1) Ford Meter Box Co.; **[A:]**
        2) Mueller Co.; **[B:]**

E. Butterfly Valves:

1. General:
    a. In full compliance with AWWA C504 and following requirements:
        1) Suitable for throttling operations and infrequent operation after periods of inactivity.
        2) Elastomer seats which are bonded or vulcanized to the body shall have adhesive integrity of bond between seat and body assured by testing, with minimum 75-pound pull in accordance with ASTM D429, Method B.
        3) Bubble-tight with rated pressure applied from either side. Test valves with pressure applied in both directions.
        4) No travel stops for disc on interior of body.
        5) Self-adjusting V-type or O-ring shaft seals.
        6) Isolate metal-to-metal thrust bearing surfaces from flowstream.
        7) Provide traveling nut or worm gear actuator with handwheel. Valve actuators to meet the requirements of AWWA C504.
        8) Buried service operators shall withstand 450 foot-pounds of input torque at fully open and fully closed positions.
        9) Provide linings and coatings per AWWA, unless otherwise indicated on Drawings or specified herein.
        10) Valves to be in full compliance with NSF/ANSI 61. Provide NSF/ANSI 61 certificate for each valve.
    b. Non-AWWA butterfly valves to meet the following actuator requirements:
        1) For above ground installations, provide handle and notch plate for valves 6 inches and smaller and heavy-duty, totally enclosed gearbox type operators with handwheel, position indicator and travel stops for valves 8 inches and larger, unless otherwise indicated on Drawings or specified herein.
2. Type V500 Butterfly Valve Water Works Service 3 Inches to 72 Inches:
    a. AWWA C504, Class 150B.
    b. Short body type, flanged ends.

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c. Cast-iron body, cast or ductile iron disc, Type 304 stainless steel shafts, Buna-N EPDM rubber seat **[D: bonded or molded in body only]**, and stainless steel seating surface.
d. Provide epoxy lining and coating in compliance with AWWA C550.
e. Manufacturers and Products:
1) Pratt; Model 2FII or Triton XR-70.
2) DeZurik; AWWA Valve.

3. Type V506 Butterfly Valve High Pressure Service 4 Inches to 48 Inches:
a. AWWA C504, Class 250B.
b. Short body type, **[A: Class 250] [B: Class 125]** flanged ends.
c. Cast or ductile iron body, cast or ductile iron disc with Type 316 stainless steel disc edge, ASTM A564/A564M Type 630 Condition H-1100/1150 or Type 316 stainless steel shaft, Buna-N rubber seat bonded or molded in body only, self-adjusting V-type multi-ring seals.
d. **[C: Provide epoxy lining [D: and coating] in compliance with AWWA C550.]**
e. Manufacturers and Products:
1) Pratt; Triton HP-250.
2) DeZurik; AWWA Flanged Class 250.
3) Mueller; Lineseal XP Class 250.

4. Type V507 Butterfly Valve High Pressure Service 4 Inches to 48 Inches:
a. AWWA C504, Class 250B.
b. Mechanical joint ends.
c. Cast or ductile iron body, cast or ductile iron disc with Type 316 stainless steel disc edge, ASTM A564/A564M Type 630 Condition H-1100/1150 or Type 316 stainless steel shaft, Buna-N rubber seat bonded or molded in body only, self-adjusting V-type multi-ring seals.
d. **[A: Provide epoxy lining [B: and coating] in compliance with AWWA C550.]**
e. Manufacturers and Products:
1) Pratt; Triton HP-250.
2) DeZurik; AWWA Mechanical Joint Class 250.
3) Mueller; Lineseal XP250.

5. Type V513 Butterfly Valve 2 Inches to 20 Inches:
a. **Lug** style, **ductile iron** body, **Type 316 stainless steel** disc, Type 316 or Type 18-8 stainless steel one-piece stem, **FKM (Viton)** replaceable resilient seat, heavy-duty self-lubricating sleeve type bushings, NBR stem seal, 150 psi working pressure rating, valve body to fit between ASME B16.1 Class 125/150 flanges.

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b. Manufacturers and Products:
1) Bray Controls; Series 30/31.
2) Tyco/Keystone; Model AR1/AR2.
3) Crane/Centerline; Series 200.

6. Type V514 High Performance Butterfly Valve 2 Inches to 36 Inches:
a. ASME B16.1 Class **[A: 150] [B: 300] [C: lug] [D: wafer]** style, high performance type, **[E: carbon steel] [F: Type 316 stainless steel]** body, Type 316 stainless steel single or double offset disc, Type 316 stainless steel shaft and taper pins, **[G: PTFE] [H: EPDM] [I: Buna-N]** seat, PTFE stem packing, stainless steel with RTFE thrust washer.
b. Manufacturers and Products:
1) Tyco/Keystone; K-Lok Series.
2) DeZurik; BHP Series.

7. Type V520 Solid Polyvinyl Chloride Butterfly Valve 1-1/2 Inches to 8 Inches:
a. Wafer body type, pressure rated 150 psi at 70 degrees F CWP, solid ASTM D1784, Type I, Grade 1, PVC body and contoured PVC or polypropylene valve disc, stainless steel valve stem, Viton seat, lever operator.
b. Manufacturers and Products:
1) ASAHI/America; Type **[A: 57]**.
2) Spears.

8. Type V530 Butterfly Valve 4 Inches to 20 Inches for Fire Protection Service:
a. UL Listed and FM Approved, **[A: wafer] [B: flanged] [C: mechanical joint]** style, AWWA C504 Class 150B valve with cast-iron body, aluminum-bronze disc, stainless steel stem, EPDM seat, geared operator with highly visible position indicator and detachable crank handle.
b. For buried service, provide post indicating assembly with detachable crank handle.
c. Manufacturer and Product: Pratt; **[D: IBV] [E: PIVA]**.

F. Check and Flap Valves:

1. Type V600 Check Valve 2 Inches and Smaller:
a. All bronze, threaded cap, threaded or soldered ends, swing type replaceable bronze disc, rated 125-pound SWP, 200-pound WOG.
b. Manufacturers and Products:
1) Stockham; Figure B-319, threaded ends.
2) Milwaukee; Figure 509, threaded ends.
3) Stockham; Figure B-309, soldered ends.
4) Milwaukee; Figure 1509, soldered ends.

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2. Type V602 Check Valve 2 Inches and Smaller:
   a. All bronze, threaded cap, threaded ends, swing type replaceable Teflon disc and bronze disc holder, rated 150-pound SWP, 300-pound WOG.
   b. Manufacturers and Products:
      1) Walworth; Figure 3412.
      2) Milwaukee; Figure 510.
3. Type V604 Check Valve 2-1/2 Inches to 12 Inches:
   a. Flanged end, cast-iron body, bronze mounted swing type, solid bronze or cast-iron disc, bronze seat ring, rated 125-pound SWG, 200-pound WOG.
   b. Manufacturers and Products:
      1) Stockham G-931; List 37, Clearway check valve.
      2) Crane Co.; Cat. No. 373.
4. Type V606 Check Valve 2 Inches to 12 Inches:
   a. Flanged end, cast-iron body, bronze mounted swing type, solid bronze or cast-iron disc, bronze seat ring, outside lever and **[A: weight,] [B: spring,]** rated 125-pound SWP, 200-pound WOG.
   b. Manufacturers and Products:
      1) Stockham; G-931.
      2) Crane Co.; Cat. No. 383.
5. Type V608 Swing Check Valve 2 Inches to 24 Inches:
   a. AWWA C508, 125-pound flanged ends, cast-iron body, bronze body seat, bronze mounted cast-iron clapper with **[A: bronze seat] [B: rubber facing]**, stainless steel hinge shaft.
   b. Valves, 2 inches through 12 inches rated 175-pound WWP and 14 inches through 24 inches rated 150-pound WWP. Valves to be **[C: plain fitted] [D: fitted with adjustable outside lever and weight] [E: fitted with adjustable outside lever and spring] [F: fitted with dual adjustable outside levers and springs]**. Increasing-pattern body valve may be used where increased outlet piping size is shown.
   c. Manufacturers and Products:
      1) M&H Valve; Style 59, 159, or 259.
      2) Mueller Co.; No. A-2600 Series.
6. Type V610 Swing Check Valve 2-1/2 Inches to 12 Inches for Fire Protection Service:
   a. UL Listed, FM Approved, iron body, bronze-mounted, rated 175 pounds WOG, self-adjusting bronze disc, ends ASME B16.1 flanged, with a 1-inch NPT tapped and plugged boss.
   b. Manufacturers and Products:
      1) Kennedy; Figure 126.
      2) Mueller; A-2120-6.

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7. Type V614 Slanting Disc Check Valve 2 Inches to 60 Inches:
   a. Slanting or tilting disc design, off-center pivot, body ductile iron two-piece design, bronze seat on 55 degree angle, disc bronze or ductile iron, pivot pin and bushing Type 304 stainless steel, Class 125, 150 psi rating, Class 125 flange drilling, **[A: bottom mounted buffer cylinder for cushion closing] [B: valve disc position indicator]**.
   b. Manufacturers and Products:
      1) APCO; Series 800.
      2) Val-Matic; Series 9800.
8. Type V615 Slanting Disc Check Valve 2 Inches to 60 Inches:
   a. Slanting or tilting disc design, off-center pivot, body ductile iron two-piece design, bronze seat on 55 degree angle, disc bronze or ductile iron, pivot pin and bushing Type 304 stainless steel, Class 250, 300 psi rating, Class 250 flange drilling, flat face, **[A: bottom mounted buffer cylinder for cushion closing] [B: valve disc position indicator]**.
   b. Manufacturers and Products:
      1) APCO; Series 800.
      2) Val-Matic; Series 9700.
9. Type V616 Slanting Disc Check Valve 2 Inches to 36 Inches:
   a. Off-center pivoting disc design, wafer style, cast-iron body, ductile iron discs, Type 316 stainless steel pivot pin, spring pin, and bushing, Buna-N disc seal, Type 316 stainless steel or Monel spring, **[A: Class 125] [B: Class 250]**.
   b. Manufacturers and Products: Daniel Flow Products; Chexter 1600 Series, Type D.
10. Type V622 Silent Check Valve 3 Inches to 24 Inches:
   a. Globe style, center guided, **[A: 125-pound] [B: 250-pound]** flanges, cast-iron body, bronze trim, **[C: Buna-N seat,]** stainless steel spring. Valves to be FM Approved in sizes up to and including 12 inches.
   b. Manufacturers and Products:
      1) APCO; Series 600.
      2) Val-Matic; 1800 Series.
      3) Cla-Val; Series 581.
11. Type V624 Silent Check Valve 4 Inches to 12 Inches for Fire Protection Service:
   a. UL Listed or FM Approved, center-guided **[A: wafer style valve,] [B: globe style valve with ASME B16.1, Class 125 flanges,]** iron body, bronze trim, stainless steel spring, rated 175-pound nonshock, CWP.
   b. Manufacturers and Products:
      1) Mueller; Steam Specialty.
      2) APCO; **[C:]**

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12. Type V630 PVC Ball Check Valve 4 Inches and Smaller:
    a. ASTM D1784, Type I, Grade 1 polyvinyl chloride body, dual union socket weld ends, rated 150 psi at 73 degrees F, and Viton seat and seal.
    b. Manufacturers and Products:
        1) Nibco; Chemtrol Tru Union.
        2) ASAHI/America.
        3) Spears; True Union.
13. Type V631 CPVC Ball Check Valve 4 Inches and Smaller:
    a. ASTM D1784 Cell Class 23477B CPVC body, single or dual union socket weld ends, rated 150 psi at 73 degrees F, 110 psi at 140 degrees F, Viton seat and seal.
    b. Manufacturers and Products:
        1) Nibco; Chemtrol Tru Union.
        2) ASAHI/America.
        3) Spears; True Union.
14. Type V632 Ball Check Valve 3 Inches and Larger:
    a. Flanged end, iron body valve with cleanout and **[A: floating] [B: sinking]** type hollow steel ball, vulcanized nitrile rubber exterior, flanges ASME B16.1, Class 125, rated 150-pound working pressure, suitable for vertical up or horizontal flow.
    b. Manufacturers and Products:
        1) FLYGT Corp; **[C:]**.
        2) Flomatic Corp.; **[D:]**.
        3) Golden Anderson; **[E:]**.
15. Type V634 Rubber Flapper Check Valve 2 Inches to 24 Inches:
    a. Iron body, ASME B16.1, Class 125 flanges, steel-reinforced Buna-N flapper raised seating ring, rated 150-pound CWP.
    b. Manufacturers and Products:
        1) APCO; Series 100.
        2) Val-Matic; “Swingflex.”
16. Type V640 Double Check Valve Backflow Prevention Assembly 3/4 Inch to 10 Inches:
    a. Two resilient seated check valves, two **[A: nonrising stem] [B: outside screw and yoke]** resilient-seated isolation valves, test cocks, in accordance with AWWA C510, rated 175 psi maximum working pressure, meets requirements of USC Foundation For Cross-Connection Control and Hydraulic Research.
    b. Manufacturers and Products:
        1) FEBCO; Model 850.
        2) Danfoss Flomatic; Model DCVE/DCV.
        3) Watts; Series 007/709.
17. Type V642 Reduced-Pressure Principle Backflow Prevention Assembly 3/4 Inch to 10 Inches:
    a. Two resilient seated check valves with an independent relief valve between the valves, two **[A: nonrising stem] [B: outside screw**

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and yoke] resilient-seated isolation valves, test cocks, in accordance with AWWA C511, rated 175 psi maximum working pressure, meets requirements of USC Foundation For Cross-Connection Control and Hydraulic Research.

b. Manufacturers and Products:
   1) FEBCO; Model 860.
   2) Danfoss Flomatic; Model RPZE/RPZ.
   3) Watts; Series 009/909.

18. Type V644 Wet Pipe Alarm Valve:
   a. Valve and Trim:
      1) UL Listed and FM Approved as a complete unit, rated 175 psi working pressure, **[A: 125-pound ASME B16.1 flanged inlet] [B: and] [C: outlet] [D: grooved end outlet]**.
      2) Supplied with full trim for **[E: horizontal flow] [F: vertical flow] [G: position as shown on Drawings]** including, but not necessarily limited to, water pressure gauges (with test valves), alarm test valve, mechanical sprinkler alarm bell connection (with strainer), pressure switch for electric alarm signal, retarding chamber, alarm and retard chamber drains, and main drain.
      3) Provide with additional valves, piping, and fittings as required for complete and fully functioning arrangement.
   b. Manufacturers and Products:
      1) Reliable Automatic Sprinkler Co., Inc.; Model E Alarm Valve.
      2) Tyco/Central; Model **[H: F] [I: G]**.
19. Type V654 Check Valve 2 Inches and Smaller for Heating, Chilled, and Cooling Service:
   a. All-bronze type silent check valve, screwed ends, rated 200-pound WOG.
   b. Manufacturers and Products:
      1) Mueller; Steam Specialty No. 203-BP.
      2) Metraflex; **[A:]**.
20. Type V690 Flap Gate 6 Inches to 96 Inches:
   a. Cast-iron body and cover, bronze-mounted, flanged frame type, dual pivot-point hinge arms, hinge arms bronze, hinge pins Type 304 stainless steel, seat bronze and impacted into grooves in body and cover flap, lubrication fittings for each pivot, upper and lower pivot adjustment.
   b. Manufacturers and Products:
      1) Rodney Hunt Co.; Series FV-AC or FV-AR.
      2) Hydro Gate; Model 50C or 50.
21. Type V692 Flap Valve 4 Inches to 30 Inches:
   a. Flange style frame, cast-iron body, bronze seats on body and cover, bronze hinge pins.

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b. Manufacturers and Products:
   1) M&H Valve; Style 47-02.
   2) Clow Valve; No. F-3012.

22. Type V694 Check Valve 1 Inch to 48 Inches:
   a. Elastomer type flanged or slip-on as shown on Drawings, round entry area to match pipe, contoured duckbilled shaped exit, flat bottom and off-set bill design, curved bill for 18 inches and larger, valve open with approximately 2 inches of line pressure and return to CLOSED position under zero flow condition, rated for 50 psi minimum operating pressure; flanges steel backing flange type, drilled to ASME B16.1, Class 125, plain-end valve attached with two Type 316 stainless steel adjustable bands, elastomer nylon-reinforced **[A: neoprene] [B: Buna-N] [C:]**.
   b. Manufacturer and Product: Red Valve Co.; Tideflex Check Valve Series TF-1 or 35-1.

G. Self-Regulated Automatic Valves:

1. Type V710 Pressure-Reducing Valve 2-1/2 Inches and Smaller:
   a. Direct diaphragm operated, spring controlled, bronze body, NPT threaded ends, 200-psig rated minimum.
   b. Size/Rating: **[A:]** inch, maximum of **[B:]** gpm, with inlet pressure of **[C:]** psig. Outlet pressure set at **[D:]** psig. **[E: As shown in Valve Schedule.]**
   c. Manufacturers and Products:
      1) Fisher; Type 75A.
      2) Watts; Series 223.
2. Type V711 Pressure-Reducing Valve 2 Inches and Smaller:
   a. Direct diaphragm, spring controlled, **[A: cast-iron] [B:]** body, spring case, **[C: composition] [D:]** seat and diaphragm, stainless steel valve stem, NPT threaded ends, 250-psig rated.
   b. Size/Rating: **[E:]** inch, maximum of **[F:]** gpm, with inlet pressure of **[G:]** psig. Outlet pressure set at **[H:]** psig. **[I: As shown in Valve Schedule.]**
   c. Manufacturer and Product: Fisher; 95 Series.
3. Type V712 Pressure-Reducing Valve 1-1/2 Inches to 2 Inches:
   a. Direct diaphragm, spring controlled, cast-iron body, aluminum diaphragm and spring case, nitrile disc/diaphragm/O-rings, internal relief, NPT threaded ends, 125-psig rated.
   b. Size/Rating: **[A:]** inch, maximum of **[B:]** scfh, with inlet pressure of **[C:]** psig. Outlet pressure set at **[D:] [E: As shown in Valve Schedule.]**
   c. Manufacturer and Product: Fisher; S200 Series.
4. Type V714 Pressure-Reducing Valve 3 Inches and Larger:
   a. Hydraulically operated, diaphragm actuated, pilot controlled globe valve, ductile iron body, ASME B16.1 Class 150 flanged ends,

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rated 250 psi, bronze or stainless steel trim, stainless steel stem, externally mounted strainers with cocks, maintains a constant downstream pressure regardless of fluctuations in flow or upstream pressure.

b. **[A: FDA approved fusion bonded epoxy lining [B: and coating] installed in accordance with AWWA C550.]**

c. Size/Rating: **[C:]** inch, maximum of **[D:]** gpm, with inlet pressure of **[E:]** psig. Outlet pressure set at **[F:]** psig. **[G: As shown in Valve Schedule.]**

d. Manufacturers and Products:
   1) Cla-Val; **[H: 90-01] [I: 690-01]** Series.
   2) Singer; Model **[J: 106PR] [K: 206PR]**.

5. Type V716 Pressure-Reducing/Back-Pressure Sustaining Valve 3 Inches and Larger:
   a. Hydraulically operated, diaphragm actuated, pilot controlled globe valve, ductile iron body, ASME B16.1 Class 150 flanged ends, rated 250 psi, bronze or stainless steel trim, stainless steel stem, externally mounted strainers with cocks, maintains a constant downstream pressure while maintaining a minimum upstream pressure.
   b. **[A: FDA approved fusion bonded epoxy lining [B: and coating] installed in accordance with AWWA C550.]**
   c. Size/Rating: **[C:]** inch, maximum of **[D:]** gpm, with inlet pressure of **[E:]** psig. Outlet pressure set at **[F:]** psig. **[G: As shown in Valve Schedule.]**
   d. Manufacturers and Products:
      1) Cla-Val; **[H: 92-01] [I: 692-01]** Series.
      2) Singer; Model **[J: 106PR-R] [K: 206PR-R]**.

6. Type V720 PVC Pressure Relief, By-Pass Relief, Back-Pressure Regulator, Back-Pressure, Anti-Siphon Valve 1/2 Inch to 2 Inches:
   a. Direct acting diaphragm, spring controlled, in-line pattern, NPT threaded inlet and outlet, 150 psi design pressure.
   b. PVC body, Teflon or Viton diaphragm, PVC or Teflon piston, high-density polyethylene or stainless steel adjusting bolt and locknut, stainless steel or coated steel spring, stainless steel fasteners.
   c. Designed to open when upstream pressure reaches setpoint; set pressure adjustable from 10 psi to 100 psi, minimum. **[A: Factory set pressure setting at [B: 25] [C:] psi for back-pressure and anti-siphon valves, [D: 10] [E:] psi for pressure relief valves, [F: 100] [G:] psi for bypass relief valves, and [H: 50] [I:] psi for back-pressure regulator valves.]**
   d. Manufacturers and Products:
      1) Plast-O-Matic; Series RVDT.
      2) Griffco; Series BPV.
      3) Primary Fluid Systems; TOP Valve.

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7. Type V722 PVC Pressure Regulating Valve, 1/2 Inch to 1-1/2 Inches:
   a. Diaphragm operated assembly, spring controlled, in-line pattern, NPT threaded inlet and outlet, 150 psi design pressure.
   b. PVC body, Viton seals and diaphragm, coated stainless steel spring, stainless steel adjusting bolt, locknut, and fasteners.
   c. Designed to regulate downstream pressure closing when pressure reaches setpoint; set pressure adjustable from 5 psi to 50 psi. **[A: Factory set pressure setting at [B:] psi.]**
   d. Manufacturers and Products:
      1) Plast-O-Matic, Series PR.
      2) Hayward; Pressure Regulator.
8. Type V725 Automatic Degassing Valve, 1/2 Inch to 3/4 Inch:
   a. PVC or CPVC construction with Viton seals, NPT threaded inlet and outlet, float designed to automatically vent gases, **[A: 100] [B: 150]** psi design pressure.
   b. Manufacturers and Products:
      1) **[C: Plast-O-Matic; Series DGV]**.
      2) Primary Fluid Systems, Inc.; Accu-Vent.
9. Type V730 Pressure-Relief Valve 2 Inches and Smaller:
   a. Direct diaphragm, spring controlled, **[A: cast-iron] [B:]** body, spring case, **[C: nitrile] [D:]** seat **[E: neoprene] [F:]** diaphragm, stainless steel valve stem, NPT threaded ends, 200 psi rated.
   b. Opens when upstream pressure reaches a maximum set point.
   c. Size/Rating: **[G:]** inch, maximum of **[H:]** gpm, with inlet pressure of **[I:]** psig. Outlet pressure set at **[J:]** psig. **[K: As shown in Valve Schedule.]**
   d. Manufacturer and Product: Fisher; 98 Series.
10. Type V732 Pressure-Relief Valve 3 Inches and Larger:
   a. Hydraulically operated, diaphragm actuated, pilot controlled globe valve, ductile iron body, ASME B16.1 Class 150 flanged ends, rated 250 psi, bronze or stainless steel trim, stainless steel stem, externally mounted strainers with cocks, to open when upstream pressure reaches a maximum set point.
   b. **[A: FDA approved fusion-bonded epoxy lining [B: and coating] installed in accordance with AWWA C550.]**
   c. Size/Rating: **[C:]** inch, set point of **[D:] psig.] [E: As shown in Valve Schedule.]**
   d. Manufacturers and Products:
      1) Cla-Val; **[F: 50-01] [G: 650-01]**.
      2) Singer; Model **[H: 106-RPS] [I: 206-RPS]**.
11. Type V740 Air and Vacuum Valve 1/2 Inch to 16 Inches:
   a. 1/2-inch through 3-inch NPT inlets and outlets, 4-inch and larger ASME B16.1 Class **[A: 125] [B: 250]** flanged inlet with plain outlet and protective hood.

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b. Rated **[C: 150] [D: 300]** psi working pressure, cast-iron or ductile iron body and cover, stainless steel float and trim, built and tested to AWWA C512. **[E: Operating pressure is [F:] psi.]**

c. Manufacturers and Products:

1) APCO Valve and Primer Corp.; Series 140 or 150.

2) Val-Matic Valve; Series 100.

12. Type V741 Air and Vacuum Valve 4 Inches to 16 Inches with Anti-Slam Device:

a. Equipped with anti-slam device to throttle flow of water into air valve. Design anti-slam device to permit full, unrestricted flow of air into and out of air valve but reduce flow area for water to approximately 10 percent.

b. Rated **[A: 150] [B: 300]** psi working pressure, cast-iron or ductile iron body and cover, stainless steel float and trim, built and tested to AWWA C512, ASME B16.1 Class **[C: 125] [D: 250]** flanged inlet and plain outlet with protective hood.

c. **[E: Provide air release valve and isolation gate valve to meet rated working pressure. Operating pressure is [F:].]**

d. Manufacturers and Products:

1) APCO Valve and Primer Corp.; Series 1900.

2) Val-Matic Valve; Series 1200/100.

13. Type V742 Air and Vacuum Valve 1/2 Inch to 16 Inches for Vertical Turbine Service:

a. Equip 1/2 inch through 3 inches with stainless steel diffuser screen to break up solid water column before coming in contact with float, manufacturer's standard double acting throttling device in outlet for throttling, NPT threaded inlet and outlet.

b. Equip 4 inches and larger with anti-slam device to throttle flow of water into air valve. Design anti-slam device to permit full, unrestricted flow of air into and out of air valve, but reduce flow area for water to approximately 10 percent. ASME B16.1 Class **[A: 125] [B: 250]** flanged inlet and NPT threaded outlet.

c. Rated **[C: 150] [D: 300]** psi working pressure, cast-iron or ductile iron body and cover, stainless steel float and trim, built and tested to AWWA C512.

d. Manufacturers and Products:

1) APCO Valve and Primer Corp.; Series 141DAT to 146DAT or Series 1904 to 1916.

2) Val-Matic Valve; Series 100WS to 116WS.

14. Type V744 Air Release Valve 1/2 Inch to 2 Inches:

a. Suitable for water service, automatically exhaust small amounts of entrained air that accumulates in a system. In CLOSED position, seat against resilient seat to prevent water leakage.

b. Rated **[A: 150] [B: 300]** psi working pressure, cast-iron or ductile iron body and cover, stainless steel float and trim, NPT threaded

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inlet and outlet, built and tested to AWWA C512. **[C: Operating pressure is [D:] psi.]**

c. Manufacturers and Products:
   1) APCO Valve and Primer Corp.; Series 50, 200, and 200A.
   2) Val-Matic Valve; Series 15A to 45.6.

15. Type V745 Air Release Valve 1/2 Inch to 1 Inch:
   a. Suitable for water service, automatically exhaust small amounts of entrained air that accumulates in system. In CLOSED position, seat against resilient seat to prevent water leakage.
   b. Rated 230-psi working pressure, **[A: reinforced nylon body] [B: cast-iron body with brass base]**, foamed polypropylene float, EPDM rolling seal, Buna-N O-ring, NPT threaded inlet. **[C: Operating pressure is [D:] psi.]**
   c. Manufacturer and Product: ARI Valves; **[E: S-050] [F: S-050-C]**.
16. Type V746 Combination Air Release Valve 1 Inch to 16 Inches:
   a. Suitable for water service, combines operating features of air and vacuum valve and air release valve. Air and vacuum portion to automatically exhaust air during filling of system and allow air to re-enter during draining or when vacuum occurs. Air release portion to automatically exhaust entrained air that accumulates in system.
   b. Valve single body or dual body, air release valve mounted on air and vacuum valve, isolation valve mounted between the dual valves. 1-inch through 3-inch valves with NPT threaded inlet and outlet, 4-inch and larger valves with ASME B16.1 Class **[A: 125] [B: 250]** flanged inlet and cover outlet.
   c. Rated **[C: 150] [D: 300]** psi working pressure, cast-iron or ductile iron body and cover, stainless steel float and trim, built and tested to AWWA C512.
   d. Manufacturers and Products:
      1) APCO Valve and Primer Corp.; Series 143C to 147C or 1804 to 1816.
      2) Val-Matic Valve; Series 201C to 203C or 104/22 to 116/38.
17. Type V747 Rolling Seal Combination Air Valve 3/4 Inch to 2 Inches:
   a. Designed for water service and uses rolling seal to allow smaller and larger amounts of air to automatically exhaust under pressure and air to enter when vacuum occurs in a single valve body.
   b. **[A: Reinforced nylon] [B: Cast-iron]** body with polypropylene discharge elbow, NPT inlet, 230 psi working pressure.
   c. Foamed polypropylene float, EPDM rubber rolling seal mechanism with reinforced nylon plug, plug cover, and clamping stem, Buna-N O-ring.
   d. Manufacturer and Product: ARI Valves; D-040 or D-040-C.
18. Type V748 Rolling Seal Combination Air Valve 2 Inches to 8 Inches:
   a. Suitable for water service, combines operating features of air and vacuum valve and air release valve. Air and vacuum portion to

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automatically exhaust air at a high rate during filling of system and allow air to re-enter during draining or when vacuum occurs. Air release portion to automatically exhaust entrained air that accumulates in system. Air release uses rolling seal mechanism.

b. High flow air/vacuum valve, cast-iron body with stainless steel float and seat, EPDM seal, ASME B16.1 Class 125 flanged inlet, 230-psi working pressure **[A: nonslam feature]**.

c. Air release valve with foamed polypropylene float, EPDM rubber rolling seal mechanism with reinforced nylon plug, plug cover, and clamping stem, Buna-N O-ring.

d. Manufacturer and Product: ARI Valves; D-060-C HF **[B: NS]**.

19. Type V750 Sewage Air and Vacuum Valve 2 Inches to 14 Inches:

a. Suitable for sewage service; automatically exhausts air during system filling and allows air to re-enter during draining or when vacuum occurs.

b. Rated working pressure of 150 psi, 1-inch through 3-inch valves with NPT threaded inlet and outlet, 4-inch and larger valves with ASME B16.1 Class 125 flanged inlet and threaded cover outlet, built and tested to AWWA C512.

c. Materials: Cast-iron or ductile iron body and cover, concave or skirted stainless steel float and trim, Buna-N seat.

d. **[A: Sewage air and vacuum valve fitted with blowoff valve, flushing valve with quick disconnect couplings, and a minimum 5 feet of hose with quick disconnect couplings to permit backflushing after installation without dismantling valve.]**

e. Manufacturers and Products:

1) APCO Valve and Primer Corp.; Series 401 SAVV to 414 SAVV.

2) Val-Matic Valve; Series 301 to 306.

20. Type V752 Sewage Air Release Valve 2 Inches to 4 Inches:

a. Suitable for sewage service; automatically exhausts entrained air that accumulates in a system.

b. Rated working pressure of 150 psi, operating pressure of **[A:]**, built and tested to AWWA C512.

c. Materials: Cast-iron or ductile iron body and cover with NPT threaded inlet and **[B: 1/2-inch] [C: 1-inch]** NPT threaded outlet, concave or skirted stainless steel float and trim; Buna-N resilient seat.

d. **[D: Sewage air release valve fitted with blowoff valve, flushing valve with quick disconnect couplings, and a minimum 5 feet of hose with quick disconnect couplings to permit backflushing after installation without dismantling valve.]**

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e. Manufacturers and Products:
    1) APCO Valve and Primer Corp.; Series 400 SARV or 450 SARV.
    2) Val-Matic Valve; Series 48 or 49.

21. Type V754 Sewage Combination Air Valve 2 Inches to 6 Inches:
    a. Suitable for sewage service; combines operating functions of air and vacuum valve and an air release valve. Air and vacuum portion shall automatically exhaust air during filling of a system and allow air to re-enter during draining or when a vacuum occurs. Air release portion to automatically exhaust entrained air that accumulates in system. Single body unit with air and vacuum valve and an air release valve in a single housing.
    b. Rated working pressure of 150 psi; built and tested to AWWA C512.
    c. Materials: Cast-iron or ductile iron body and covers, NTP threaded inlet and outlet, with concave or skirted stainless steel float and trim.
    d. **[A: Sewage air release valve fitted with blowoff valve, flushing valve with quick disconnect couplings, and a minimum 5 feet of hose with quick disconnect couplings to permit backflushing after installation without dismantling valve.]**
    e. Manufacturers and Products:
        1) APCO Valve and Primer Corp.; Series 440 SCAV.
        2) Val-Matic Valve; Series 800.

22. Type V756 Sewage Combination Air and Vacuum Valve 6 Inches to 14 Inches:
    a. Suitable for sewage service; combines operating functions of air and vacuum valve and an air release valve using separate valves connected together. Air and vacuum valve shall automatically exhaust large quantities of air during system filling and allow air to re-enter during draining or when a vacuum occurs. Air release valve to automatically exhaust small quantities of entrained air that accumulates in system.
    b. Rated working pressure of **[A: 150 psi, operating pressure of [B:]] [C: 300 psi]**.
    c. Materials: Cast-Iron or Ductile Iron Body:
        1) Air and Vacuum Valve:
            a) Upper and lower concave or skirted stainless steel float and trim.
            b) Inlet Flanges: ASME B16.1 Class **[A: 125] [B: 250]** pound.
            c) Outlet: **[C: Hooded.] [D: Flanged.]**
            d) Seat: Buna-N.
        2) Air Release Valve: 2-inch NPT threaded inlet and 1/2-inch NPT threaded outlet; Buna-N seat.

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d. Provide with all-bronze blow-off and flushing gate valves for each valve, all-bronze isolation gate valve between air and vacuum valve and air release valve; 5-foot rubber hose with quick disconnect couplings.
e. **[E: Provide with inlet butterfly isolation valve.]**
f. Manufacturer and Product: APCO Valve and Primer Corp.; Series 400C.

23. Type V757 Sewage Rolling Seal Combination Air Valve 2 Inches to 8 Inches:
    a. Designed for sewage service, uses rolling seal to allow smaller and larger amounts of air to automatically exhaust under pressure and air to enter when a vacuum occurs in a single valve body. Body designed to allow sewage solids to flow out of valve.
    b. **[A: Stainless steel] [B: Epoxy coated steel]** funnel shaped body with ASME B16.1 Class 150 flanged inlet and access flanges, reinforced nylon combination air and vacuum valve assembly and polypropylene discharge elbow, 250-psi working pressure, all-bronze drain/flush valve, flushing connection.
    c. Foamed polypropylene float, EPDM rubber rolling seal mechanism with reinforced nylon plug, plug cover, and clamping stem, Buna-N O-ring.
    d. Manufacturer and Product: ARI Valves; D-020.
24. Type V760 Dual Chamber Booster Pump Control Valve 2-1/2 Inches to 16 Inches:
    a. Hydraulically operated, diaphragm actuated, pilot controlled globe valve with ductile iron body, ASME B16.1 Class 150 flanged ends, rated 250 psi, bronze or stainless steel trim, stainless steel stem, externally mounted strainer with cock. **[A: FDA approved fusion bonded epoxy lining [B: and coating] installed in accordance with AWWA C550.]**
    b. Manufacturers and Products:
        1) Cla-Val; Model 60-11.
        2) Singer; Model 106-BPC.
25. Type V770 Dual Chamber Deep Well Pump Control Valve 2-1/2 Inches to 16 Inches:
    a. Hydraulically operated, diaphragm actuated, solenoid controlled globe valve with ductile iron body, ASME B16.1 Class 150 flanged ends, rated 250 psi, bronze or stainless steel trim, stainless steel stem, and externally mounted strainer with cock.
    b. **[A: FDA approved fusion bonded epoxy lining [B: and coating] installed in accordance with AWWA C550.]**
    c. Manufacturers and Products:
        1) Cla-Val; Model 61-02.
        2) Singer; Model 106-DW.

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H. Miscellaneous Valves:

1. Type V900 Diaphragm Valve 1/2 Inch to 12 Inches:
   a. Weir type, **[A: polypropylene-lined] [B: hard rubber-lined] [C: _____-lined]** cast-iron body, ASME B16.1 flanged ends, manual operator indicating, rising stem type with handwheel, diaphragm **[D: ethylene propylene,] [E: neoprene,] [F: Buna-N,]** in accordance with MSS SP-88 Category B.
   b. Manufacturers and Products:
      1) ITT Engineered Valves; **[G:]**.
      2) Saunders Valve, Inc.; **[H:]**.
2. Type V901 Diaphragm Valve 1/2 Inch to 12 Inches:
   a. Straight-through type, **[A: polypropylene-lined] [B: hard rubber-lined] [C: _____-lined]** cast-iron body, ASME B16.1 flanged ends, manual operator indicating, rising stem type with handwheel, diaphragm **[D: ethylene propylene,] [E: neoprene,] [F: Buna-N,]** in accordance with MSS SP-88, Category B.
   b. Manufacturers and Products:
      1) ITT Engineered Valves; **[G:]**.
      2) Saunders Valve, Inc.; **[H:]**.
3. Type V903 Diaphragm Valve, 1/2 Inch to 4 Inches:
   a. Weir type with **[A: PVC Type 1, Grade 1] [B: CPVC Type 4, Grade 1] [C: PVDF] body, [D: Viton (FKM) diaphragm] [E: PTFE with EPDM backing diaphragm] [F: PTFE with EPDM or Viton backing and with PVDF gas barrier diaphragm]**, **[G: double union design, solvent weld socket ends] [H: flanged ends]**, handwheel operator, position indicator, adjustable travel stop, clear molded acrylic stem cap.
   b. Manufacturers and Products:
      1) ASAHI/AMERICA; Diaphragm Valve Type 14.
      2) ITT Engineered Valves; Dia-Flo.
      3) Saunders Valve; Diaphragm Valve.
4. Type V905 Pinch Valve 1 Inch to 12 Inches:
   a. Cast-iron fully enclosed body, epoxy lined and coated, ASME B16.1 Class 125 flanged ends, one-piece molded Buna-N elastomer tube, full-port design, 90 psi minimum working pressure, double-acting upper and lower pinch bars that close on centerline, stainless steel stem, handwheel operator, position indicator, geared operator for valves 6 inches and larger.
   b. Manufacturers and Products:
      1) Red Valve Co.; Series 75.
      2) RF Technologies, Inc.; RF Valve.
5. Type V910 Telescoping Scum Collection Valve:
   a. Rack and pinion type with offset floor stand and cast-iron offset floor stem incorporating rack guides, pinion, and handwheel supports. Rack and pinion and connecting rods Type 304 stainless

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steel, slip pipe brass with flat weir-crest skimming funnel, cast-iron pipe companion flange, O-ring seal and gasket for connection to discharge pipe. Skimming funnel minimum top diameter of 8 inches.

b. Valve, 4 inches nominal and continuously adjustable from a high point of **[A: 1.5] [B:]** feet below bottom of floor stand to a low point **[C: 5.50] [D:]** feet below bottom of floor stand.

c. Anchor Bolts: Type 316 stainless steel.

d. Manufacturers and Products:

1) Link-Belt Division of FMC Corp.; **[E:]**.

2) Envirex Division of Rexnord Corp.; **[F:]**.

6. Type V915 Mud Valve 4 Inches to 24 Inches:

a. Cast-iron frame, yoke, and gate; heavy-duty 125-pound flange style, bronze seat, Buna-N seal, **[A: nonrising stem] [B: rising stem]**, bronze stem and stem nut, 2-inch square operating nut, **[C: cast-iron floor box,] [D: Type 304 stainless steel extension stem; stem guides spaced for L/R of 200 maximum]**.

b. Manufacturers:

1) Troy Valve.

2) Trumbull Industries, Inc.

3) Clow Valve Company.

7. Type V916 Cast Stainless Steel Mud Valve 4 Inches to 20 Inches:

a. Heavy-duty CF8M stainless steel yoke, flange, guides, and gate; **[A: SBR rubber] [B: Buna-N]** seat mechanically retained with Type 316 stainless steel fasteners, **[C: nonrising stem] [D: rising stem]**. Stainless steel casting to be passivated per ASTM A380. Type 316 stainless steel one-piece stem with integral thrust collar and coated with antigalling compound.

b. **[E: Stem extension one-piece Type 316 stainless steel,] [F: 2-inch operating nut,] [G: 14-inch diameter ductile iron handwheel,] [H: indicating stainless steel floorstand and wall bracket.] [I: floor box with position indicator.] [J: wall bracket with position indicator.]** Stem guides Type 316 stainless steel with bronze bushings for L/R of 200 maximum. Cast top and bottom stem couplings Type 316 stainless steel.

c. Manufacturers:

1) Troy Valve.

2) Trumbull Industries, Inc.

8. Type V920 Hydrostatic Pressure Relief Valve, Floor Type 4 Inches:

a. Floor type, cast-iron body, grate, and cover, removable cover and strainer, body with integral seep ring, body length as shown on Drawings, neoprene rubber cover seat, epoxy body seat.

b. Manufacturers and Products:

1) M&H Valve; Style 147, F-1493.

2) Clow Valve; Figure F-1493.

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9. Type V921 Hydrostatic Pressure Relief Valve, Wall Type 4 Inches:
    a. Wall type, flange style frame, cast-iron body and cover, bronze seat body, resilient rubber seat on cover, bronze hinge pins, cast-iron wall pipe with integral seep ring and strainer, length as shown on Drawings.
    b. Manufacturers and Products:
        1) M&H Valve; Style 147, F-1494/F-1496.
        2) Clow Valve; Figure F-1494/F-1496.
10. Type V925 Sampling Valve:
    a. Type 316 stainless steel wetted parts, hand operated iron crank, piston to extend to inner surface of vessel or pipe, sealed by two compressible replaceable Teflon rings, one above discharge port and other below discharge port, **[A: 3/4-inch NPT inlet and 3/4-inch NPT outlet] [B: 1-inch NPT inlet and 1-inch NPT outlet]**.
    b. Manufacturers and Products:
        1) Strahman Valves, Inc.; Piston Type Sampling Valve.
        2) Fetterolf Corporation; Rod-Seal Sampling Valve.
11. Type V930 Fire Hydrant: (Describe agency standard.)
12. Type V940 Solenoid Valve 1/4 Inch to 2 Inches:
    a. Two-way internal pilot operated diaphragm type, brass body, resilient seat suitable for air or water, solenoid coil molded epoxy, NEMA insulation Class F, 120 volts ac, 60-Hz, unless otherwise indicated. Solenoid enclosure NEMA 250, Type 4 unless otherwise indicated. Size and normal position (when de-energized) as indicated on **[A:]**.
    b. Minimum operating pressure differential no greater than 5 psig, maximum operating pressure differential not less than 125 psig.
    c. Manufacturers and Products:
        1) ASCO; **[B:]**
        2) Skinner; **[C:]**
13. Type V950 Manual In-Line Lockout/Tagout Valve 1/4 Inch to 1-1/4 Inches for Air Service:
    a. Manual in-line, three-port, heavy-duty cast aluminum body, NPT threaded ports, tee-handle, aluminum spool, stainless steel spring, nitrile seals, suitable for air pressures 0 psig to 250 psig. Safety yellow body with contrasting black, red or blue handle.
    b. Lockout/tagout valve for compliance to OSHA 29 CFR Part 1910.147. Full flow in open position, exhausts downstream air in closed position, lockable in closed position.
    c. Complete with NPT male threaded aluminum exhaust silencer with internal mesh element, lockout hasp.
    d. Manufacturers and Products:
        1) Norgren; In-Line Lockout Valve Series C00.
        2) Parker Pneumatic; LV Series.
        3) Ross Controls; L-O-X Valve.

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14. Type V951 Manual Soft-Start In-Line Lockout/Tagout Valve 1/4 Inch to 1-1/4 Inches for Air Service:
    a. Manual in-line, three-port, single unit type, heavy-duty cast aluminum body, NPT threaded ports, tee-handle, aluminum spool, stainless steel spring, nitrile seals, suitable for air pressures 30 psig to 150 psig. Safety yellow body with contrasting black, red or blue handle.
    b. Lockout/tagout valve with soft start feature for compliance to OSHA 29 CFR Part 1910.147. Full flow in open position, exhausts downstream air in closed position, lockable in closed position, soft-start feature to allow gradual air pressure buildup.
    c. Complete with NPT male threaded aluminum exhaust silencer with internal mesh element, lockout hasp.
    d. Manufacturers and Products:
        1) Parker Pneumatic; EZ Series.
        2) Ross Controls; L-O-X/EEZ-ON Valve.

2.06 OPERATORS AND ACTUATORS

A. Manual Operators:

1. General:
    a. For AWWA valves, operator force not to exceed requirements of applicable valve standard. Provide gear reduction operator when force exceeds requirements.
    b. For non-AWWA valves, operator force not to exceed applicable industry standard or 80 pounds, whichever is less, under operating condition, including initial breakaway. Provide gear reduction operator when force exceeds requirements.
    c. Operator self-locking type or equipped with self-locking device.
    d. Position indicator on quarter-turn valves.
    e. Worm and gear operators one-piece design, worm-gears of gear bronze material. Worm of hardened alloy steel with thread ground and polished. Traveling nut type operator’s threaded steel reach rod with internally threaded bronze or ductile iron nut.
2. Exposed Operator:
    a. Galvanized and painted handwheel.
    b. Cranks on gear type operator.
    c. Chain wheel operator with tieback, extension stem, floor stand, and other accessories to permit operation from normal operation level.
    d. Valve handles to take a padlock, and wheels a chain and padlock.
3. Buried Operator:
    a. Buried service operators on valves larger than 2-1/2 inches shall have a 2-inch AWWA operating nut. Buried operators on valves 2 inches and smaller shall have cross handle for operation by

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forked key. Enclose moving parts of valve and operator in housing to prevent contact with the soil.

b. Buried service operators to be grease packed and gasketed to withstand submersion in water to 20 feet minimum.

c. Buried valves shall have extension stems, bonnets, and valve boxes.

B. **[A: Electric Operators, 120 Volts:**

1. **General:**
   a. **Unit shall be low profile to reduce amount of required space and weigh 15 pounds or less.**
   b. **Size to 1-1/2 times required operating torque. Motor stall torque not to exceed torque capacity of the valve.**
   c. **Provide operator mounting bracket to mount operator to valve providing minimal torque to piping system when operating.**
2. **Operator Operation, General:**
   a. **Suitable for full 90-degree rotation of quarter-turn valves.**
   b. **Manually override handwheel.**
   c. **Mechanical valve position indication.**
3. **Electronic Control:**
   a. **Torque Limiting Switches: Two single pole, double throw mechanical switches. Switches operate at any point in valve travel.**
   b. **Jammed-valve detection and protection.**
   c. **Motor over-temperature detection and protection.**
   d. **Travel limit switches, single pole double throw.**
4. **Open-Close (O/C) Service:**
   a. **Duty cycle for intermittent ON-OFF operation shall be 25 percent.**
   b. **Operator shall power to OPEN and power to CLOSE.**
   c. **Local Indication and Control:**
      1) **Integral mechanical valve POSITION indication, 0 percent to 100 percent OPENED.**
      2) **Integral OPENED and CLOSED indication lights.**
      3) **Integral LOCAL-OFF-REMOTE (L-O-R).**
      4) **Integral OPEN maintained switch which causes the valve to stroke full OPENED, even if OPEN switch is released, while L-O-R switch is in LOCAL.**
      5) **Integral CLOSE maintained switch which causes valve to stroke full CLOSED, even if CLOSED switch is released, while L-O-R switch is in LOCAL.**

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d. **Remote Indication and Control:**
   1) **Relay contact that closes when valve is capable of being controlled remotely (L-O-R switch in REMOTE) for connection to and monitoring by plant control system.**
   2) **Limit switch that closes when valve is fully OPENED for connection to and monitoring by plant control system.**
   3) **Limit switch that closes when valve is fully CLOSED for connection to and monitoring by plant control system.**

e. **Modulating (M) Service:**
   1) **Operator rated for continuous duty with servo shall be rated for 100 percent modulating operation.**
   2) **Operator shall modulate based on an externally applied 4 mA to 20 mA dc signal.**
   3) **Operator shall be equipped with an electronic servo module for valve modulation.**
      a) **Module shall provide serial communications with provided cable for setup of valve operation.**

f. **Local Indication and Control:**
   1) **Integral mechanical valve POSITION indication, 0 percent to 100 percent OPENED.**
   2) **Integral OPENED and CLOSED indication lights.**
   3) **Integral LOCAL-OFF-REMOTE (L-O-R).**
   4) **Integral OPEN momentary switch which causes valve to stroke towards OPENED, as long as OPEN switch is held, while L-O-R switch is in LOCAL.**
   5) **Integral CLOSE momentary switch which causes valve to stroke towards CLOSED, as long as CLOSED switch is held, while L-O-R switch is in LOCAL.**
   6) **Position valve proportionally 0 to 100 percent OPEN with external 4 mA to 20 mA dc signal while in REMOTE.**

g. **Remote Indication and Control:**
   1) **Relay contact that closes when valve is capable of being controlled remotely (L-O-R switch in REMOTE) for connection to and monitoring by plant control system.**
   2) **Limit switch that closes when valve is fully OPENED for connection to and monitoring by plant control system.**
   3) **Limit switch that closes when valve is fully CLOSED for connection to and monitoring by plant control system.**
   4) **Current Position Transmitter, 4 mA to 20 mA dc signal in proportion to 0 percent to 100 percent OPENED, with 0.5 percent accuracy and 0.5 percent repeatability, capable of driving a 750-ohm load, for connection to and monitoring by Plant Control System.**

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5. **Control Features: Electric motor actuators with features as noted above, and as modified/supplemented in Electric Actuated Valve Schedule.**
6. **Manufacturer and Product: Rotork; [B:].]**

C. **[A: Electric Motor Actuators, 480 Volts:**

1. **General:**
   a. **Comply with latest version of AWWA C542.**
   b. **Size to 1-1/2 times required operating torque. Motor stall torque not to exceed torque capacity of valve.**
   c. **Controls integral with actuator and fully equipped as specified in AWWA C542.**
   d. **Stem protection for rising stem valves.**
2. **Actuator Operation—General:**
   a. **Suitable for full 90-degree rotation of quarter-turn valves or for use on multiturn valves, as applicable.**
   b. **Manual override handwheel.**
   c. **Valve position indication.**
   d. **Operate from FULL CLOSED to FULL OPEN positions or the reverse in the number of seconds given in Electric Actuated Valve Schedule.**
   e. **[B: Nonintrusive Electronic Control: Local controls, diagnostics, and calibration, including limit and torque settings, shall be accomplished nonintrusively. Electronic valve position display with capability to show continuous torque output. If applicable, provide two hand-held configuration units for every 10 actuators provided, two minimum.]**
3. **Open-Close(O/C)/Throttling(T) Service:**
   a. **Size motors for one complete OPEN-CLOSE-OPEN cycle no less than once every 10 minutes.**
   b. **Actuator suitable for throttling operation of valve at intermediate positions.**
   c. **LOCAL-OFF-REMOTE Selector Switch, padlockable in each position:**
      1) **Integral OPEN-STOP-CLOSE momentary pushbuttons with seal-in circuits to control valve in LOCAL position.**
      2) **Remote OPEN-STOP-CLOSE momentary control dry contact inputs in REMOTE position. Integral seal-in circuits for remote OPEN and CLOSE commands; valve travel stops when remote STOP contact opens.**
      3) **Auxiliary contact that closes in REMOTE position.**
   d. **OPEN and CLOSED indicating lights.**
   e. **Integral reversing motor starter with built-in overload protection.**

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4. **Modulating (M) Service:**
    a. **Size actuators for continuous modulating duty.**
    b. **Feedback potentiometer, or equivalent, and integral electronic positioner/comparator circuit to maintain valve position.**
    c. **HAND-OFF-AUTO (Local-Off-Remote) Selector Switch, padlockable in each position:**
        1) **Integral OPEN-STOP-CLOSE momentary pushbuttons with seal-in circuits to control valve in HAND (Local) position.**
        2) **4 mA to 20 mA dc input signal to control valve in AUTO (Remote) position.**
        3) **Auxiliary contact that closes in AUTO (Remote) position.**
    d. **OPEN and CLOSED indicating lights.**
    e. **Ac motor with solid state reversing starter or dc motor with solid state reversing controller, and built-in overload protection. Controller capable of 1,200 starts per hour.**
    f. **Duty cycle limit timer and adjustable band width, or equivalent, to prevent actuator hunting.**
    g. **Valve position output converter that generates isolated 4 mA to 20 mA dc signal in proportion to valve position, and is capable of driving into loads of up to 500 ohms at 24 volts dc.**
5. **Limit Switch:**
    a. **Single-pole, double-throw (SPDT) type, field adjustable, with contacts rated for 5 amps at 120 volts ac.**
    b. **Each valve actuator to have a minimum of two auxiliary transfer contacts at end position, one for valve FULL OPEN and one for valve FULL CLOSED.**
    c. **Housed in actuator control enclosure.**
6. **Control Features: Electric motor actuators with features as noted above, and as modified/supplemented in Electric Actuated Valve Schedule.**
7. **Manufacturers and Products:**
    a. **Rotork Controls; [C:].**
    b. **Flowserve Limitorque; [D:].**
    c. **AUMA; [E:].]**

D. Pneumatic Actuators:

1. General:
    a. Actuator complete with air sets, exhaust mufflers, speed controls, pilot solenoids, safety vented isolation valves, and accessories.
    b. Suitable for full operation range of valve at air supply pressure indicated.
    c. Position indication and stop limiting devices on all actuators.

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2. Vane Style Actuator:
    a. In compliance with AWWA C541.
    b. Air supply of **[A: 80 psig] [B:]**.
    c. Pressure die-cast aluminum housing with corrosion resistant fusion bonded epoxy finish, stainless steel bolting, stainless steel adjustable end stops.
    d. Electroless nickel-plated steel shaft and vane, single-component machined or cast part.
    e. Dual-opposed polyurethane lip seals with stainless steel expander.
    f. Double Acting:
        1) Complete with mounting hardware.
        2) Suitable for non-lubrication air.
    g. Spring Return:
        1) Wound stainless steel spring type in separate housing.
        2) Attached to pneumatic actuator housing.
    h. Geared Manual Override: Geared type with de-clutchable handwheel, torque rated for application.
    i. Visual Indicator: High visibility, OPEN-CLOSED indication, color coded, chemical resistant, clear polycarbonate cover.
    j. Manufacturers:
        1) Kinetrol.
        2) K-Tork.
3. Cylinder Actuator:
    a. In compliance with AWWA C541.
    b. Air supply pressure of **[C: 80 psig] [D:]**.
    c. Nonswivel type totally enclosed:
        1) Travel stops and position indicator.
        2) Factory lubricated and sealed requiring no additional lubrication.
    d. Double Acting:
        1) Nonmetallic for operation on nonlubricated air.
        2) Handwheel override independent of cylinder.
    e. Spring Return:
        1) Open, closed, or throttling, steel cylinder with air line lubricators. Nonlubricated air may be used if certified by manufacturer.
        2) Modulating: Nonmetallic for operation on nonlubricated air.
        3) Manual override manufacturer’s standard.
    f. Actuators used on quarter-turn valves to include a totally enclosed valve actuating mechanism. Actuating mechanism to be factory lubricated and sealed.
    g. Manufacturers and Products:
        1) Rotork.
        2) DeZurik.

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4. Diaphragm Actuator:
    a. Spring return with steel or aluminum diaphragm case and spring barrel, steel spring and actuator stem, and fabric-reinforced neoprene diaphragm.
    b. Actuators used on quarter-turn valves to include a totally enclosed valve actuating mechanism. Actuating mechanism to be factory lubricated and sealed.
    c. Diaphragm actuators sized and configured for service indicated and air supply pressure of **[E: 35 psig] [F:]**.
    d. Manufacturers and Products:
        1) Fisher Controls; Type 1051.
        2) Keystone Valve; Figure 723.
5. Accessories:
    a. Air Set: Pressure regulator with internal relief, filter, outlet pressure gauge, and adjustable reduced pressure range as required by valve actuator.
        1) Aluminum body and handwheel.
        2) Safety vented lockout isolation valve.
        3) Gauge range 1-1/3 to 2 times maximum operating pressure.
        4) Manufacturers and Products:
            a) Fisher Controls; Type 67 AFR.
            b) Masoneilan; No. 77-4.
    b. Air Exhaust Muffler:
        1) In the exhaust port of actuator pilot solenoid valves.
        2) Manufacturers and Products:
            a) Barry Wright Corp.; **[G:]**.
            b) Allied Witan Co.; **[H:]**.
    c. Limit Switch:
        1) Single-pole, double-throw (SPDT) type, rated 10 amps at 120 volts ac.
        2) Housed in NEMA 4X enclosure.
        3) Adjustable for OPEN and CLOSED valve positions.
    d. Positioner:
        1) For modulating actuators, shall be pneumatic force balance instruments to control valve position as a function of input signal. Accomplish positive positioning of valve by a mechanical feedback connection from valve actuating mechanism. Position feedback through a characterized linear cam to allow adjustment of valve positioning and input signal. Positioner suitable for double acting or spring return actuator.
        2) Positioner to have zero and span adjustment and be field reversible for direct or reverse action.
        3) Gauges for supply and output pressure and for input signal pressure.

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4) Positioner for 3 psig to 15 psig pneumatic input signal or 4 mA to 20 mA dc input signal as indicated.
5) Positioner for dc input signal with transducers shall convert electrical signal to appropriate pneumatic signal. Transducer integral with positioner or separate component. If separate, factory mount transducer on pneumatic operator. Line electric power not required for transducer.
6) Corrosion-resistant enclosures for positioners and transducers to be splash-proof and moisture-proof with gasketed covers.

e. Pilot Solenoid Valve:
1) Solenoid valve shall pilot control actuator in appropriate configuration for type of open-close actuator being controlled. Double acting actuator shall have four-way solenoid valve, and spring return actuator shall have three-way solenoid valve. Dual coil valve shall not change position unless one coil is energized while the other is de-energized.
2) Pilot operated diaphragm type solenoid valve with brass body and resilient seat. Valve with minimum operating pressure differential no greater than 10 psig and maximum operating pressure differential no less than 150 psig. Internal parts corrosion-resistant. Solenoid valve to have Class F molded coils for operation on 120 volts ac, 60-Hz, unless otherwise indicated. Solenoid enclosure as defined in **[I: NEMA 250, Type 4X] [J:]**.
3) Manufacturers and Products:
a) Asco Red Hat; **[K:]**.
b) C. A. Norgren Co.; **[L:]**.

6. Open-Close and Throttling Valve:
a. Double Acting Cylinders: Four-way solenoid with dual coils.
b. Spring Return Cylinders: Three-way solenoids, spring return.
7. Modulating Valve: Positioner with 4 mA to 20 mA input signal, unless otherwise indicated.
8. Control Features: Pneumatic actuators with features noted in the Pneumatic Actuated Valve Schedule.

2.07 ACCESSORIES

A. Tagging: 1-1/2-inch diameter heavy brass or stainless steel tag attached with No. 16 solid brass or stainless steel jack chain for each **[A: valve operator] [B: valve] [C: valve [D:] inch and larger]**, bearing valve tag number shown on **[E: Electric Actuated Valve Schedule] [F: Pneumatic Actuated Valve Schedule] [G: Self-Regulated Valve Schedule] [H: Drawings]**.

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B. Limit Switch:

1. Factory installed NEMA 4X limit switch by actuator manufacturer.
2. **[A: SPST, rated at 5 amps, 120 volts ac.] [B:]**

C. T-Handled Operating Wrench:

1. **[A:]** each galvanized operating wrenches, 4 feet long.
2. Manufacturers and Products:
   a. Mueller; No. A-24610.
   b. Clow No.; F-2520.
3. **[B:]** each galvanized operating keys for cross handled valves.

D. Extension Bonnet for Valve Operator: Complete with enclosed stem, extension, support brackets, and accessories for valve and operator.

1. Manufacturers and Products:
   a. Pratt; **[A:]**.
   b. DeZurik; **[B:]**.

E. Floor Stand:

1. Nonrising, heavy pattern, indicating type.
2. Complete with solid extension stem, coupling, handwheel, stem guide brackets, and yoke attachment. Stem length as required to connect valve operating nut and floor stand.
3. Stem Guide: Space such that stem L/R ratio does not exceed 200.
4. Anchor Bolts: Type 304 stainless steel.
5. Manufacturers and Products:
   a. Clow; Figure F-5515.
   b. Mueller, Figure A-26426.

F. Floor Box:

1. Plain type, for support of nonrising type stem.
2. Complete with solid extension stem, operating nut, and stem guide brackets. Stem length as required to extend valve operating nut to within 3 inches of finish floor.
3. Stem Guide: Space such that stem L/R ratio does not exceed 200.
4. Anchor Bolts: Type 304 stainless steel.
5. Manufacturers and Products:
   a. Neenah Foundry; R 7506.
   b. Clow; No. F5690.

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G. Chain Wheel and Guide:

1. Handwheel direct-mount type.
2. Complete with chain.
3. Galvanized or cadmium-plated.
4. Manufacturers and Products:
   a. Clow Corp.; Figure F-5680.
   b. Walworth Co.; Figure 804.
   c. DeZurik Corp.; Series W or LWG.

H. Cast-Iron Valve Box: Designed for traffic loads, sliding type, with minimum of 5-1/4-inch ID shaft.

1. Box: Cast iron with minimum depth of 9 inches.
2. Lid: Cast iron, minimum depth 3 inches, **[A: nonlocking type,] [B: locking type,]** marked **[C: WATER] [D: SEWER] [E: GAS] [F:]**.
3. Extensions: **[G: Cast iron.] [H: Cast iron, ABS, or PVC pipe.]**
4. Two-piece box and lid for valves 4 inches through 12 inches, three-piece box and lid for valves larger than 12 inches with base sized for valve.
5. Valve extension stem for valves with operating nuts 3 feet or greater below finish grade.
6. Manufacturers and Products:
   a. East Jordan Iron Works; Cast-Iron Valve Boxes.
   b. Bingham & Taylor; Cast-Iron Valve Boxes.

I. Concrete Valve Box: Designed for traffic loads, sliding type, with minimum of 10-inch ID shaft.

1. Box: High-density, reinforced concrete, minimum depth 12 inches, cast-iron ring seat.
2. Lid: Cast iron, minimum depth 3 inches, marked **[A: WATER] [B: SEWER] [C: GAS] [D:]**.
3. Extensions: **[E: Concrete.] [F: ABS, PVC, or cast-iron pipe.]**
4. Manufacturers and Products:
   a. Christy Concrete Products; G Series.
   b. BES Concrete Products; G Series.

J. Indicator Post Assembly:

1. Cast or ductile iron post head, bell, and wrench with cast or ductile iron or steel barrel.
2. Plexiglas or equal protected window to indicate OPEN and CLOSED position.
3. Padlockable eye bolt for wrench.
4. Adjustable bury depth. Bury depth as required for valve installation.

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5. UL Listed and FM Approved.
6. Manufacturers and Products:
    a. Clow; Style 2945.
    b. Mueller; A-20806.

PART 3 EXECUTION

3.01 INSTALLATION

A. Flange Ends:

1. Flanged valve bolt holes shall straddle vertical centerline of pipe.
2. Clean flanged faces, insert gasket and bolts, and tighten nuts progressively and uniformly.

B. Screwed Ends:

1. Clean threads by wire brushing or swabbing.
2. Apply joint compound.

C. PVC and CPVC Valves: Install using solvents approved for valve service conditions.

D. Valve Installation and Orientation:

1. General:
    a. Install valves so handles operate from fully open to fully closed without encountering obstructions.
    b. Install valves in location for easy access for routine operation and maintenance.
    c. Install valves per manufacturer’s recommendations.
2. Gate, Globe, and Ball Valves:
    a. Install operating stem vertical when valve is installed in horizontal runs of pipe having centerline elevations 4 feet 6 inches or less above finished floor, unless otherwise shown.
    b. Install operating stem horizontal in horizontal runs of pipe having centerline elevations greater than 4 feet 6 inches above finish floor, unless otherwise shown.
3. Eccentric Plug Valves:
    a. Unless otherwise restricted or shown on Drawings, install valve as follows:
        1) Liquids with suspended solids service with horizontal flow: Install valve with stem in horizontal position with plug up when valve is open. Install valve with seat end upstream (flow to produce unseating pressure).
        2) Liquids with suspended solids service with vertical flow: Install valve with seat in highest portion of valve (seat up).

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3) Clean Liquids and Gas Service: Install valve with seat end downstream of higher pressure when valve is closed (higher pressure forces plug into seat).

4. Butterfly Valves:
   a. Unless otherwise restricted or shown on Drawings, install valve a minimum of 8 diameters downstream of a horizontal elbow or branch tee with shaft in horizontal position.
   b. For vertical elbow or branch tee immediately upstream of valve, install valve with shaft in vertical position.
   c. For horizontal elbow or branch tee immediately upstream of valve, install valve with shaft in horizontal position.
   d. When installed immediately downstream of swing check, install valve with shaft perpendicular to swing check shaft.
   e. For free inlet or discharge into basins and tanks, install valve with shaft in vertical position.
5. Check Valves:
   a. Install valve in accordance with manufacturer's instructions and provide required distance from immediate upstream fitting.
   b. Install valve in vertical flow (up) piping only for gas services.
   c. Install swing check valve with shaft in horizontal position.
   d. Install double disc swing check valve to be perpendicular to flow pattern when discs are open.
6. Solenoid Valves: Install in accordance with manufacturer's instructions.

E. Install line size ball valve and union upstream of each solenoid valve, in-line flow switch, or other in-line electrical device, excluding magnetic flowmeters, for isolation during maintenance.

F. Install safety isolation valves on **[A: compressed air] [B: fuel oil] [C:]**.

G. Locate valve to provide accessibility for control and maintenance. Install access doors in finished walls and plaster ceilings for valve access.

H. Extension Stem for Operator: Where depth of valve operating nut is 3 feet or greater below finish grade, furnish operating extension stem with 2-inch operating nut to bring operating nut to a point within 6 inches of finish grade.

I. Torque Tube: Where operator for quarter-turn valve is located on floor stand, furnish extension stem torque tube of a type properly sized for maximum torque capacity of valve.

J. Floor Box and Stem: Steel extension stem length shall locate operating nut in floor box.

K. Chain Wheel and Guide: Install chain wheel and guide assemblies or chain lever assemblies on manually operated valves over 6 feet 9 inches above finish floor. Install chain to within 3 feet of finish floor. Where chains hang in

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normally traveled areas, use appropriate “L” type tie-back anchors. Install chains to within operator horizontal reach of 2 feet 6 inches maximum, measured from normal operator standing location or station.

3.02 TESTS AND INSPECTION

A. Valve may be either tested while testing pipelines, or as a separate step.

B. Test that valves open and close smoothly under operating pressure conditions. Test that two-way valves open and close smoothly under operating pressure conditions from both directions.

C. Inspect air and vacuum valves as pipe is being filled to verify venting and seating is fully functional.

D. Count and record number of turns to open and close valve; account for discrepancies with manufacturer’s data.

E. Set, verify, and record set pressures for relief and regulating valves.

F. Automatic valves to be tested in conjunction with control system testing. Set opening and closing speeds, limit switches, as required or recommended by Engineer.

G. Test hydrostatic relief valve seating; record leakage. Adjust and retest to maximum leakage of 0.1 gpm per foot of seat periphery.

3.03 MANUFACTURER’S SERVICES

A. Valve(s) as listed below require manufacturer’s field services:

1. **[A: V504,] [B: V754,] [C:]**.

B. Manufacturer’s Representative: Present at Site for minimum person-days listed below, travel time excluded:

1. **[A:]** person-days for **[B: installation assistance] [C: and] [D: inspection]**.
2. **[E:]** person-days for **[F: functional] [G: and] [H: performance]** testing and completion of Manufacturer’s Certificate of Proper Installation.

C. See **[A: Section 01 43 33, Manufacturers’ Field Services,] [B: and] [C: Section 01 91 14, Equipment Testing and Facility Startup.]**

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3.04 SUPPLEMENTS

A. The supplements listed below, following “End of Section,” are part of this Specification.

1. Electric Actuated Valve Schedule.
2. Self-Regulated Valve Schedule.

END OF SECTION

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SECTION 40 27 05
PLUNGER VALVES

PART 1 GENERAL

1.01 DESCRIPTION

A. Furnish horizontal in-line 10-inch plunger valve assembly, complete with electric modulating type actuator and aeration device if specified for flow control and isolation, factory tested, and operable, as shown on Drawings, and as specified herein.

1.02 RELATED WORK SPECIFIED ELSEWHERE

A. Section 09 90 00, Painting and Coatings.

B. Section 26 20 00, Low Voltage AC Induction Motors.

1.03 REFERENCES

A. The following is a list of standards which may be referenced in this Section:

1. American National Standards Institute (ANSI):
   a. B1.20.1, Pipe Threads, General Purpose (Inch).
   b. B16.1, Cast Iron Pipe Flanges and Flanged Fittings.
   c. B16.5, Steel Pipe Flanges and Flanged Fittings.
2. American Iron and Steel Institute (AISI):
   a. 304, Austenitic Stainless Steel (maximum percent: 0.08C, 2.0 Mn, 1.0 Si, 18-20 Cr, 8-10.5 Ni).
   b. 420, Martensitic Stainless Steel (minimum percent: 0.15C, maximum percent: 1.0 Mn, 1.0 Si, 12-14 Cr, 0.0 Ni,).
3. ASTM International (ASTM):
   a. A48, Specification for Gray Iron Castings.
   b. A216, Specification for Steel Casting, Alloy, Specially Heat-Treated, for Pressure Containing Parts, Suitable for High Temperature Service.
   c. A536, Specification for Common Requirements for Iron Castings for General Industrial Use.
   d. A743, Specification for Castings, Iron-Chromium, Iron-Chromium-Nickel, Corrosion Resistant, for General Application.

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1.04 SUBMITTALS

A. Submittals shall be made to the Construction Manager.

B. Submit Manufacturer's data and descriptive literature written in the English language with quotation. Include catalog data, preliminary performance testing procedures, quality control procedures, calculations, detailed construction sheets showing all valve parts and descriptions of materials of construction with and applicable USA material specifications such as AISI, ANSI, ASTM, American Society of Automotive Engineers (SAE), or the Copper Development Association (CDA). Identify each valve by tag number to which the catalog data and detail sheets pertain.

C. Furnish for approval prior to manufacture, factory developed production drawings that clearly show valve dimensions, laying lengths, port sizes, component parts, and materials of construction. Provide graphical factory generated computer modeling results for both estimated noise levels in decibels and for cavitation and its control through the complete stroke of the valve and through all flow rates.

D. Furnish for approval prior to manufacture shop assembly drawings that clearly shows dimensions and orientation of valve actuators as installed on the valves. Clearly show location of internal stops for gear actuators. Provide valve actuator safety verification through the complete stroke specifically noting values for both break torque under maximum differential as well as maximum dynamic torque. Use the ratio of actuator output torque over valve input torque for validation. Valve manufacturer's compliance shall be factory signed and dated.

E. Furnish for approval prior to manufacture shop coating and lining specifications, which clearly identify all valve linings and coatings.

F. During manufacture, furnish coating and lining test reports that report and verify the valve interior lining condition is tested for absence of holidays, and lining thickness. Describe test results and repair procedures for each valve. Do not ship valves to project site until the reports have been approved by the Construction Manager and accepted by the Owner.

G. Furnish for approval prior to manufacture a valve summary data sheet that provides the station, valve structure, type, manufacturer, size, pressure rating, drilling pattern and model number of each valve; and type, manufacturer and model number of the valve actuator.

H. Furnish for approval prior to shipping six copies of factory shop hydrostatic test reports, functional performance test reports, and any other required test reports. Hydrostatic test reports shall be presented which reflects the requirement of the test procedures.

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I. Submit for approval factory export packaging specifications, applicable to overseas shipping via surface carrier.

J. Submit for information with proposal current quality assurance program certificate of compliance.

K. Furnish Operations and Maintenance Manual for valve(s). Manuals shall include installation instructions, maintenance procedures and operation parameters. Detail operating characteristics, limiting conditions, performance cures, engineering data, nameplate data, tests, complete nomenclature and parts numbers, parts list, illustrations, assembly drawings showing each part and part number and diagrams of required maintenance. Provide spare parts ordering instructions. Identify routine maintenance and schedule for such, troubleshooting guides, adjustment and checking procedures, list of relay settings, control and alarm contact settings. Provide recommended spare parts list and current prices and recommended quantities. List briefly each maintenance operation required, frequency required and lubricant (or other material) required. Refer to specific information in manufacturer's standard maintenance manual, where applicable. Provide local representative and corporate representative and their phones, emails, names and addresses.

L. Four bound copies, and one CD of the Operations and Maintenance Manual are to be provided with the valve. The manuals shall include installation instructions, maintenance procedures and operation parameters.

1.05 SUBSTITUTION

A. Where plunger valves are shown, or specified in Project specifications and Drawings, no Contractor may substitute any other style of valve that has not been specifically approved by the Owner and Engineer for that application.

1.06 EXTRA MATERIALS

A. Furnish, tag, and box for shipment and storage following spare parts and special tools.

Item	Quantity
Special tools required to maintain or dismantle	1 complete set

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1.07 QUALITY ASSURANCE

A. The manufacturer shall be ISO 9001 and ISO 14001 Certified.

B. Shop Inspection: The manufacturer shall provide a 4-week advance notice to the Construction Manager prior to performing tests, and shall allow full access to designated Owner's representatives for inspection of manufacturing facilities and processes, and any specified testing. The manufacturer shall perform all testing at manufacturer's cost, unless such testing is specifically indicated to be provided by the Owner.

C. Shop Testing: Plunger valves shall be shop tested prior to shipment in accordance with the following minimum standards:

1. Leakage Test: Plunger valves shall be qualitatively tested to 1.1 times valve pressure rating to identify drop tight closure of valve seat, seal leaks and other problems in the assembly process.
2. Hydrostatic Test: Plunger valves shall be hydrostatically tested to withstand 1.5 times of the valve's maximum design operating pressure rating.
3. Functional Flow Performance Test: Plunger valves shall be subjected to an operational/test using potable water. The test procedure shall include three complete open/close cycles of operation with the valve actuator settings in place (limit switches, torque switches, pilot pressure settings, etc.).

1.08 EXPERIENCE AND SERVICE RESPONSE

A. Valve manufacturer shall have a minimum of 10 years of experience in production and sales of plunger valves. Valve manufacturer shall have at least 25 installed plunger valve references in North America that have been in operation in last 5 years. Valve manufacturer shall provide complete documentation to meet this requirement, including contact names and telephone and fax numbers that can verify field installations. Acceptance of the validity of submitted documentation is solely at the discretion of the client.

B. Valve manufacturer shall provide 24-hour manufacturer's response for any field service requirement. Approved service agents, licensee(s), or representatives of the manufacturer shall be permitted as long as the valve manufacturer is present. The valve manufacturer shall be responsible for its authorized agents and licensees.

1. A detailed manufacturer signed service call write up, inclusive of photo-documentation, shall be provided without exception, by the valve manufacturer.

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2. The valve manufacturer shall be required to know and keep data files on all work performed, modifications and remediations as well as the agents performing the work.
3. This data shall be permanently kept with the manufacturer regardless of licensee.

1.09 NATIONAL SANITATION FOUNDATION (NSF) STANDARD 61 ANNEX G

A. The entire plunger valve must have verifiable Certification of Compliance with the NSF 61 Annex G - Drinking Water System Components Standard. Certifications shall accompany submittals.

PART 2 PRODUCTS

2.01 PLUNGER VALVE PERFORMANCE REQUIREMENTS

A. Performance: Valve shall be designed to operate smoothly throughout the specified flow range without cavitation, excessive noise, or vibration for the conditions stated below.

1. Valve manufacturer shall notify Construction Manager in writing of any risk of cavitation damage to the piping downstream of the plunger valves due for the operating conditions indicated on Drawings and Specifications and suggest elongating straight piping downstream of the valve if such modifications are deemed needed to protect the downstream piping (including valves) from cavitation damage.
2. During startup and training, plunger valve manufacturer shall educate Owner staff of any cavitation and maintenance issues or concerns to watch for in operating the valves.

B. Noise: Operating noise levels shall not exceed 95 decibels (dBA) at a distance of 3 feet from the valve at the normal flow point. Material stresses shall not exceed 1/5 of the ultimate or 1/3 of the yield strength of the material. Flow rate as a function of pressure drop across the valve shall be linear to within 3 percent.

C. Flow Control Plunger Valve Operation Data:
Intended valve use is to provide flow control and energy dissipation for flow and head Conditions identified below.
1. Design Condition 1 - Finished Water Pump Station Start-up and Testing.

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Design Condition 1		Value	Units
Normal Operating Range		0.789 to 8.355	cfs
Maximum Operating Flow		10.0	cfs
Minimum Operating Flow		0	cfs
Inlet Pressure	0 cfs	174.00	psig
Outlet Pressure		0	psig
Inlet Pressure	8.355 cfs	184.5	psig
Outlet Pressure		0	psig

a. Discharge to stilling basin as shown on Drawings.

b. Operating Function: Throttling flow during plant startup and testing. Valve shall function as modulating flow control valves with flow setting and flow "dead band" width (flow variation from setting where valve will not move) setting selected to maintain head on pump simulating Finished Water Pipeline head losses. Flows will be read at a meter upstream of valve.

2. Design Condition 2 - Draining of Finished Water Pipe Line.

Design Condition 2		Value	Units
Normal Operating Range		0-3.5	cfs
Maximum Operating Flow		10.0	cfs
Minimum Operating Flow		0	cfs
Max Inlet Pressure	0 cfs	174.00	psig
Min Inlet Pressure		5.00	psig
Outlet Pressure		0	psig
Max Inlet Pressure	3.5 cfs	184.5	psig
Min Inlet		0	psig

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Design Condition 2		Value	Units
Pressure			
Outlet Pressure		0	psig

a. Discharge to stilling basin as shown on Drawings.

b. Operating Function: Modulating/throttling flow control valve. Valve shall function as modulating flow control valves with flow setting and flow "dead band" width (flow variation from setting where valve will not move) setting selected control system based on inlet pressure to control draining of Finished Water Pipeline in a safe and controlled manner. Flows will be calculated based on differential pressure across the valve.

2.02 PLUNGER VALVE REQUIREMENTS

A. Valve Assembly Components: Each plunger valve assembly shall consist of a flanged short conical inlet section having an internal cone to divert the water flow into the annular chamber of the body section.

1. 8-inch plunger valve shall be an ANSI Class 150 valve with compatible flanges as specified in Section 02500, General Piping Requirements.

B. An oval body section with an inner annular chamber shall be formed by the body shell. The plunger with custom designed cylinder control trim is part of internal slider-crank mechanism and is driven by an outside 90-degree AWWA worm gear. The control trim cylinder shall be field removable and replaceable with alternate control trim when hydraulic conditions change or new operating parameters are required.

C. The plunger shall move in an axially flow direction to reduce or enlarge the annular flow cross-section through slots in a degressive manner, and the medium will flow through the customized regulating cylinder from the outer annular chamber to the inner chamber of the plunger, shall be provided for flow control.

D. The seals of the plunger valve shall allow the valve to be drip and bubble tight in both flow directions for the long term and without the need for premature seal replacement. The outside of the plunger shall seat against a quad O-ring sealing ring. The quad O-ring shall deflect and seal in both axial directions. The quad O-ring will provide the best available design for both modulating and for open close service in the prevention of twist, roll and point loading of the plunger seal. The seal shall be insensitive to debris. The elastomeric profile sealing ring shall seat leak tight at the downstream end of the plunger.

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The elastomeric profile sealing ring shall be mechanically retained in the downstream flange of the valve body by a stainless steel seat ring. Valve shaft seals shall prevent the long term potential of water entering into the gear case. The valve operating shaft shall have five O-ring seals; two on the shaft at the crank mechanism and three on the shaft at the gear box. The O-ring seals shall maintain a drip tight seal regardless of modulation cycles or inactivity. The O-ring seals will prevent corrosion of the shaft body bore.

E. The minimum closure time of the 8-inch plunger valve shall be 5 minutes from full open to full close.

F. Valves shall be provided with 4 integral feet per each 180-degree circumference. There shall be four total lifting lugs, one per each foot. The four lifting lugs shall be factory drilled and taped. They shall be sufficiently broad in placement to assist with rigging of an unbalanced load.

G. The valve shall function properly and without issue within any 180-degree flange rotation.

2.03 PLUNGER VALVE DESIGN FEATURES

A. Plunger valve shall be a one-part-body design with interior geometry that provides water flow that is guided around a streamlined internal body. The design shall feature a geometrically optimized design, a continuous annular cross-sectional reduction from inlet to throttle cross-section, and continuous rise of flow velocity to the exit without producing cavitation.

B. Plunger valve design shall feature a customized designed plunger with tailored anti-cavitation trim with slots or orifice holes to minimize cavitation. Slots or orifice shall be fully closed when the valve is placed in the CLOSED position. The plunger shall be seated against the upstream quad O-ring and an elastomeric seat located in body downstream flange with the valve in the CLOSED position. The elastomeric seat shall be properly kept in position in a groove in the body and the downstream stainless steel seat ring shall secure the elastomeric profile sealing ring from displacement. The profile seat ring shall not be penetrated by fasteners, exposed to the flow stream in the OPEN position and shall not be subject to cold flow of the elastomer.

C. Plunger valve design, when open during operation, shall feature plunger assembly movement in the upstream side direction to release water through the slots or orifice holes.

D. Plunger valve design shall feature advance and retract axial strokes of the plunger, guided in the internal body by an internal slider-crank mechanism of stainless steel. The crank and push rod mechanism shall have an industry standard 90-degree angle of rotation stroke from open to close matching the

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travel for AWWA waterworks quarter turn valves. The provided actuator shall include a mechanical stop in the OPEN and CLOSED positions which will prevent attempts of actuator to hyper extend the plunger or place undesired stresses on the internal linkage system. The plunger shall slide and be contained in the axial position by guide rails. To prevent possible corrosion between the guide rails and the valve body, the guide rails shall be completely fused to the valve body in an overlay weld process to prevent any gaps or corrosion pathways. Guide rails which are riveted or bolted to the valve body are not acceptable for long-term operability and corrosion protection. The guide rails shall be bronze and shall be positioned around the plunger in an uneven quantity to reduce the potential for damaging harmonic vibration, clogging or excessive wear. The guide rails shall be low to no lead and very low zinc content to prevent dezincification.

E. Motion shall be controlled by means of electric actuator attached to the body section.

F. The design of the annular throat cross section in any position of the plunger shall ensure linear regulation of flow.

G. Actuate plunger valve as specified and described in Section 15203, Electric Motor Actuators.

H. Flanged connections shall mate with adjacent flanges per Section 02500, General Piping Requirements.

I. The movement of the plunger shall be controlled by means of maintenance free irreversible, self-locking, quarter turn, 90-degree AWWA worm gear unit with externally adjustable mechanical stops to limit valve travel in both the OPEN and CLOSED positions. The valve stroke shall equal 90 degrees plus or minus 2 degrees, whereby the mechanical stops of the worm gear shall be engaged before the full extension or retraction of the plunger. In no instance shall the full output torque of actuator be allowed to be transmitted to the valve at its end of travel, either open or closed, without engaging the travel stops of the worm gear first. The AWWA worm gear unit shall be operated by a hand wheel or electric actuator. Only pneumatic or hydraulic cylinder actuators may utilize scotch yoke linkages to change linear piston force to rotational torque. As scotch yoke output torques are inconstant through their complete stroke, the submittals shall mathematically validate the actuator output torques exceed the required valve input torque, inclusive of AWWA safety factors, through the full stroke of the valve.

J. Plunger Valve Base Plates: Submit and obtain approval for, and provide, base plates for plunger valve. Base plates must be able to be unbolted to remove

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the valve from the adjacent process piping by sliding the valve up to 3 inches horizontally away from the upstream flange before it is lifted vertically. Base plates shall secure valve to a reinforced concrete base (by installation contactor) so that the plunger valve does not vibrate.

2.04 MATERIAL REQUIREMENTS

A. Principal Component Parts Materials of Valve Construction:

Item	Size	Material	Specification
Valve Body	All	Ductile Iron	ASTM A536, GR. 60,40,18 Coating/Lining: Manufacturer's Standard Fusion Bonded Epoxy
Plunger	All	Stainless Steel	AISI 304
Regulating Cylinder	ALL	Stainless Steel	AISI 304
Shaft Bushing		Bronze	ASTM C90800/CuSn12
Crank Shaft	All	Stainless Steel	AISI 420
Crank Mechanism (sizes 6" – 78")	All	Stainless Steel	AISI 304 / ASTM A351 CF8
Seat / Retaining Ring	All	Stainless Steel	AISI 304
Plunger Guide Rails	All	Bronze welded overlay	CuAl8 (lead <0.0020% Zinc < 0.008%
Quad-Sealing-Ring	All	EPDM	hardness A:80, (=/- 5). Elongation >200%, Tensile >12 N/mm, Elasticity >25%
Profile Sealing Ring	All	EPDM	hardness A:80, (=/- 5). Elongation >200%, Tensile >12 N/mm, Elasticity >25%
O-Rings, Actuator Shaft	All	EPDM	hardness A:80, (=/- 5). Elongation >200%, Tensile >12 N/mm, Elasticity >25%

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Item	Size	Material	Specification
Worm Gearbox			Housing: Ductile Iron GGG-40 Worm Wheel: GGG-60 or bronze Coupling: Quenched and tempered steel acc. to 10083-2 Input Drive Shaft (Secondary Gear): Stainless steel 10088-3

B. Fasteners: All studs, bolts, washers, and nuts in contact with water shall be Type 316 stainless steel.

C. All materials of moving components in contact with each other shall be of dissimilar hardness to prevent galling. The valve shall be moved through an open-close-open cycle three times after final assembly and prior to shipment to ensure this requirement.

D. The valve manufacturer coating process shall include post preparation and coating application assurances of targeted performance. The manufacturer shall utilize and incorporate a QC process that includes Coating thickness Testing, Holiday Free Testing, Cross Linkage Testing, Impact Resistance Testing, Coating Adhesion Testing and Cathodic Disbonding Testing. The Quality Compliance testing shall remain on record with the manufacturer and available for review and approval.

E. The valve shall be blast coated to near white metal. The blast cleaned body shall be then thoroughly cleaned to remove all dust, grease, oil or other negative adhesion potentials. It shall meet the coating manufacturers recommended duration for humidity and temperature and at coating application. Coating shall take place within 12 hours of the blast cleaning process.

F. Coating/Lining: Manufacturer’s standard fusion bonded epoxy and shall be holiday free.

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2.05 AERATION DEVICES AND ORIFICE PLATES

A. Where specifically indicated, the anti-cavitation venting device shall be mounted directly downstream of the plunger valve with air intake connecting piece on the top of venting system. The venting shall be in annular flow shape directly at the outlet of the plunger valve.

B. The anti-cavitation venting device shall be manufactured out of ASTM A283 steel with one flat faced flange at upstream side, flanges with one flat faced flange at downstream side, and flange on the top of anti-cavitation venting device for connection of venting pipe.

2.05 DOUBLE OFFSET BALL VALVE

A. Plunger valve manufacture to provide full port double offset ball valve installed by contractor upstream of the plunger valve. The ball valve will be used for isolating the plunger valve for maintenance.

B. The entire ball valve must have verifiable Certification of Compliance with the NSF 61 Annex G - Drinking Water System Components Standard. Certifications shall accompany submittals.

C. Allowed leakage through the valve at minimum and maximum operating heads shall be drop-tight, no leakage.

D. Valve Body: Body shall be two piece design, full-dimensioned with a minimum body shell thickness as specified in AWWA C507. Body shall be ductile cast iron ASTM A536-77, Gr 65-45-12. Welded steel design will not be accepted. Valve shall feature an inspection port atop the valve body with inspection port cover made of carbon steel A105.

E. Flanges: Flanges shall be ANSI Class 150 rated.

F. Valve Support: Pads shall be provided on the valve body for transmitting the vertical load to a pedestal below the valve. Ball valve shall come with base plate and foundation plate made in carbon steel, base plate shall be bolted into four valve legs, and foundation plate shall be encased into foundation and come with four (4) level adjustment screws. These two plates are bolted together and the baseplate shall be able to slide against foundation plate to release the thrust stress, one wear resist plastic sheet of polyamide 66 shall be placed between these two steel plates in order to reduce the friction. Pedestal anchors and all fasteners for base plate mounting shall be provided by the manufacturer.

G. Valve Markings: The following information, as a minimum, shall be cast in raised letters on the valve body, or permanently attached using a stainless

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steel or brass nameplate: manufacturers' name or symbol, year assembled, size, rated working pressure, and direction of flow.

H. Valve Ball: Ball design shall be of the double-offset arrangement with full port opening. Resilient seat shall be a full 360-degree continuous seal and shall not be in compression with the valve full open.

I. Valve Seat: Seat shall be resilient, EPDM. Seal shall be on the downstream ball segment, retained by a mechanically attached retaining ring. Seal and ring shall be accessible by removal of the pipe section downstream of the valve. The sealing ring shall be replaceable without removing the valve from the upstream pipe. Seat retainer and mating surface shall be ASTM A276 Type 304Ti stainless steel, retained by stainless steel clamps, rings and 304Ti stainless steel bolts. Seat retention designs that use bonded seats or epoxy injection for a wedging effect will not be accepted. Replacement and/or adjustment of the resilient seat shall be possible without removing the valve or valve ball from the pipeline via inspection port access.

J. Valve Shaft: Shaft shall be of the two-piece stub-shaft configuration, extending into the valve ball. Shaft shall be manufactured of stainless steel, ASTM A564 Type 630, HT 1100 or ASTM A276 Type 431, heat treated. Shafts shall be securely fixed into the valve ball, with non-slip geometry or sufficient dowels and keys as required to resist all internal pressures and operating torques. Shaft shall be keyed at the 6:00 or 12:00 positions to indicate the closed position.

K. Shaft Bushings: Bushings shall be designed by the manufacturer to ensure that they provide effective, long-lasting bearing surfaces for the support of the valve shaft without binding, dragging, or damaging the shaft under continuous full pressure differential loading conditions. Shaft bushings shall be contained in the integral hubs of the valve body and shall be of a one-piece "self-lubricated sleeve" design constructed of bronze-backed solid lubricant or PTFE material. Bearings or bushings shall be bronze sleeves lined with self-lubricating anti-friction material, Kamatics Karon V, or equal. Grease bearings will not be accepted.

L. Shaft Thrust Bearings: Bearings shall be factory-set, two-way thrust bearing on the valve shaft which shall be capable of being adjusted in the field without re-drilling, without re-pinning, and without the use of special tools. Where the valve shaft engages the thrust bearing, the valve shall be equipped with a thrust stub shaft cover or stub shaft end cover utilizing either an O-Ring seal or an asbestos-free gasket to prevent leakage. The use of packing and/or thread seal washers to prevent leakage will not be accepted.

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M. Shaft Seals: the seal may be of the self-adjusting Chevron design or O-ring design, provided that the manufacturer has at least 5 years operating experience with the seal arrangement proposed. Alternately, Seals shall be of the stuffing box and pull down packing gland type such that the packing can be adjusted or completely replaced without disturbing any part of the valve or actuator assembly except the packing gland follower. Packing shall be of the non-asbestos self-adjusting split-V or square type.

N. Paint and coatings: The manufacturer is required to have and follow a system of valve preparation and coating which assures a quality holiday free application and which maximizes the available multi-decade protection the coating offers. Manufacturers that do not properly prepare or coat their valves properly will not be accepted.

O. The manufacturer must provide their written system of valve preparation and coating. This document shall include the methodologies used (quality compliance) as well as post application review (quality assurance). It will be based on a professional system of coating and grading such as NACE, SSPC, GSK, ISO or DIN and will include both text and color photo-documentation. The manufacturers coating system must be documented as well as implemented with a quality assurance program to prevent unacceptable deviation. This coating system shall be submitted for approval.

2.06 PLUNGER AND DOUBLE OFFSET BALL VALVE MANUFACTURERS

A. Erhard.

B. VAG.

C. Approved equal.

PART 3 EXECUTION

3.01 INSTALLATION

A. Valve installation shall be in strict accordance with the manufacturer's printed recommendations, and the Contract Documents.

3.02 WORKMANSHIP

A. Valves shall be free from manufacturing defects and shall be manufactured in a workmanlike manner. Valves shall be manufactured under the direction of a registered professional engineer.

B. Surface preparation and coating/lining per Manufacturer’s standard and as specified in Section 09 90 00, Paint and Coating. Touch-up repair in accordance with Manufacturer’s written procedures.

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C. A Certificate of Compliance with the purchaser's material specifications, and the manufacturer's quality assurance program shall be furnished with each valve.

3.03 FIELD TESTING AND PERFORMANCE

A. Manufacturer shall furnish all required startup assistance and inspection of installed valve at the Owner's facility.

B. Valves supplied under this Specification shall be field leak tested by the Contractor to the specified operating pressure in the CLOSED position and shall not leak. Field leakage relevant to the plunger valve shall be corrected by the manufacturer at the manufacturer's expense. Field leakage test results shall be certified by the Construction Manager, manufacturer's onsite representative, and Contractor.

C. Plunger valves shall be subjected to onsite performance testing as part of the commissioning activities in accordance with a written performance test plan. To the extent possible, the valve shall be subjected to variable flow conditions, and the resulting control settings, flow, upstream and downstream pressures, noise levels, and vibration levels shall be documented and compared to the manufacturer's shop test results. Operational flow testing shall be performed on each valve as specified in Section 01650, Facility Startup.

3.04 WARRANTY

A. The plunger valve manufacturer shall warrant its products, including actuators incorporated in the work, to be free from defects in materials, workmanship and performance for a period of 5 years from the date of recording the Notice of Completion. Upon notice by the Owner, any damage or defect found during the warranty period shall be promptly repaired or replaced by the manufacturer at no cost to the Owner.

END OF SECTION

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SECTION 40 42 13
PROCESS PIPING INSULATION

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Society of Heating, Refrigerating and Air Conditioning Engineers Inc. (ASHRAE): 90.1, Energy Standard for Buildings Except Low-Rise Residential Buildings.
2. ASTM International (ASTM):
    a. B209, Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
    b. C165, Standard Test Method for Measuring Compressive Properties of Thermal Insulations.
    c. C177, Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus.
    d. C518, Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.
    e. C534/C534M, Standard Specification for Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.
    f. C547, Standard Specification for Mineral Fiber Pipe Insulation.
    g. C552, Standard Specification for Cellular Glass Thermal Insulation.
    h. C585, Standard Practice for Inner and Outer Diameters of Thermal Insulation for Nominal Sizes of Pipe and Tubing.
    i. C1136, Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation.
    j. C1729, Standard Specification for Aluminum Jacketing for Insulation.
    k. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
    l. E96/E96M, Standard Test Methods for Water Vapor Transmission of Materials.
3. International Code Council (ICC): International Energy Conservation Code (IECC).
4. Underwriters Laboratories Inc. (UL).

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1.02 SUBMITTALS

A. Action Submittals: Manufacturer's descriptive literature.

B. Informational Submittals: Maintenance information.

PART 2 PRODUCTS

2.01 PIPE AND FITTING INSULATION

A. Type 1—Elastomeric:

1. Material: Flexible elastomeric pipe insulation, closed-cell structure in accordance with ASTM C534/C534M.
2. Temperature Rating: Minus 297 degrees F to 220 degrees F.
3. Nominal Density: 3 pcf to 6 pcf.
4. Conductivity in accordance with ASHRAE 90.1 and maximum numerical value of 0.25 Btu-in./hr-square foot degrees F at 75 degrees F per ASTM C177 or ASTM C518.
5. Maximum water vapor transmission of 0.06 perm-inch per ASTM E96/E96M, Procedure A.
6. Joints: Manufacturer's adhesive.
7. Flame Spread Rating: Less than 25 per ASTM E84.
8. Smoke Developed Index: Less than 50 per ASTM E84.
9. Manufacturers and Products:
   a. Nomaco; K-Flex.
   b. Armacell; AP Armaflex.

B. Type 2—Fiberglass:

1. Material: UL rated, preformed, sectional bonded fiberglass per ASTM C585 with factory applied, Kraft paper with aluminum foil vapor barrier jacket with pressure-sensitive, self-sealing lap.
2. Insulation Temperature Rating: Zero to 850 degrees F.
3. Conductivity in accordance with ASHRAE 90.1 and maximum numerical value of 0.23 Btu-in./hr-square foot degrees F at 75 degrees F.
4. Jacketing per ASTM C1136 with minimum water vapor transmission for jacket of 0.02 perm-inch per ASTM E96/E96M. Furnish with no jacket if field finish system specified.
5. Joints: Matching pressure-sensitive butt strips for sealing circumferential joints.
6. Flame Spread Rating: Less than 25 per ASTM E84.
7. Smoke Developed Index: Less than 50 per ASTM E84.
8. Manufacturers and Products:
   a. Owens Corning Fiberglass; ASJ/SSL-11.
   b. John Manville; Micro-Lok with Jacket.

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C. Type 3—Foamglass:

1. Material: Cellular glass per ASTM C552.
2. Nominal Density: 7.5 pcf.
3. Compressive Strength: 90 psi per ASTM C165.
4. Temperature Rating: Minus 450 degrees F to 900 degrees F.
5. Conductivity in accordance with ASHRAE 90.1 and maximum numerical value of 0.29 Btu-in./hr-square foot degrees F.
6. Minimum water vapor transmission for insulation of 0.00 perm-inch per ASTM E96/E96M.
7. Joints: Matching pressure-sensitive butt strips for sealing circumferential joints.
8. Flame Spread Rating: 0 per ASTM E84.
9. Smoke Developed Index: 0 per ASTM E84.
10. Follow manufacturer's recommendation, based upon temperature of piping to be insulated.
11. Manufacturer and Product: Pittsburgh Corning; Foamglas One.

2.02 ROOF DRAIN AND OVERFLOW DRAIN SUMP INSULATION

A. Type 1: 1 inch thick.

2.03 INSULATION AT PIPE HANGERS AND SUPPORTS

A. Refer to Section 40 05 15, Piping Support Systems.

B. Copper, Ductile Iron, and Nonmetallic Pipe: High-density insert, thickness equal to adjoining insulation of Type 3 or other rigid insulation or manufactured pre-insulated pipe hanger and insulation shield. Extend insert beyond shield.

C. Steel Pipe: Insulation saddle or high-density insert, thickness equal to adjoining insulation of Type 3 or other rigid insulation or manufactured pre-insulated pipe hanger and insulation shield at support location. Extend insert beyond shield.

2.04 INSULATION FINISH SYSTEMS

A. Type F1—PVC:

1. Polyvinyl chloride (PVC) jacketing, minimum 20 mils indoors and 30 mils outdoors, for straight run piping and fitting locations, temperatures to 140 degrees F.
2. Color: PVC jacketing shall be color coded to match colors listed in pipe schedule where suitable matching colors are available. If no suitable colors are available jacketing shall be white.
3. Flame Spread Rating: 25 per ASTM E84.

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4. Smoke Developed Index: 50 per ASTM E84.
5. Manufacturers and Products:
    a. Knauf Insulation; Proto 1000.
    b. Johns Manville; Zeston 2000 or 300.
    c. Speedline; 25/50 Smoke-Safe.

B. Type F2—Paint:

1. Type 1 Insulation: Acrylic latex paint, white, and suitable for outdoor use.
    a. Manufacturer and Product: Armacell; WB Armaflex finish.
2. Type 2 Insulation: In accordance with Section 09 90 00, Painting and Coating.

C. Type F3—Aluminum:

1. Aluminum Roll Jacketing: For straight run piping, wrought aluminum Alloy 3003, 5005, 1100, or 3105 to ASTM B209 with H-14 temper, in accordance with ASTM C1729, minimum 0.016-inch thickness, with smooth mill finish.
2. Vapor Barrier: Provide factory applied vapor barrier, heat and pressure bonded to inner surface of aluminum jacketing.
3. Fitting Covers: Material as for aluminum roll jacketing, premolded, one or two piece covers, which includes elbows, tee/valves, end caps, mechanical line couplings, and specialty fittings.
4. Manufacturers:
    a. RPR Products; Insul-Mate.
    b. ITW, Pabco-Childers.

D. Type F4—Foamglass Jacketing:

1. Type 3 Insulation—Buried and Up to 1 Foot Above Grade: 70-mil bituminous resin with woven, glass fabric, aluminum foil layer, and plastic film coating, self-sealing manual pressure seals; Pittsburgh Corning Pittwrap SS.
2. Type 3 Insulation—Greater that 1 Foot Above Grade: 30-mil modified bituminous membrane with self-sealing manual pressure seals; Pittsburgh Corning Pittwrap CW30.

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PART 3 EXECUTION

3.01 APPLICATION

A. General:

1. Insulate valve bodies, flanges, and pipe couplings.
2. Insulate and vapor seal hangers, supports, anchors, and other piping appurtenances that are secured directly to cold surfaces.
3. Do not insulate flexible pipe couplings and expansion joints.
4. Service and Insulation Thickness: Refer to Supplement Service and Insulation Thickness table following “End of Section” and to Piping Schedule in Section 40 27 00, Process Piping—General.

3.02 INSTALLATION

A. General:

1. Install in accordance with manufacturer’s instructions and as specified herein.
2. Install after piping system has been pressure tested and leaks corrected.
3. Install over clean dry surfaces.
4. Use insulating cements, lagging adhesives, and weatherproof mastics recommended by insulation manufacturer.
5. Do not allow insulation to cover nameplates or code inspection stamps.
6. Run insulation or insulation inserts continuously through pipe hangers and supports, wall openings, ceiling openings, and pipe sleeves, unless otherwise shown.
7. Install removable insulation sections on devices that require access for maintenance of equipment or removal, such as unions and strainer end plates.
8. Personnel Protection: Install on pipes from floor to 8 feet high. Install on pipes within 4 feet of platforms and to 8 feet high above platforms.

B. Connection to Existing Piping: Cut back existing insulation to remove portion damaged by piping revisions. Install new insulation.

C. Cold Surfaces: Provide continuous vapor seal on insulation on cold surfaces where vapor barrier jackets are used.

D. Placement:

1. Insulate valves and fittings with sleeved or cut pieces of same material.
2. Seal and tape joints.

E. Heat Traced Piping: Apply insulation after heat-tracing work is completed and inspected.

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F. Roof Drains: Insulate vertical drops from roof drains to horizontal pipe, exposed and concealed horizontal piping, and 2 feet down on vertical risers from horizontal pipe.

G. Roof Drains and Overflow Drains: Insulate entire pipe runs. Where roof and overflow drains exist through an exterior wall ensure annular space between pipes and walls are properly sealed prior to insulating.

H. Roof Drain and Overflow Drain Sumps: Insulate entire sumps.

I. Vapor Barrier:

1. Provide continuous vapor barrier at joints between rigid insulation and pipe insulation.
2. Install vapor barrier jackets with pipe hangers and supports outside jacket.
3. Do not use staples and screws to secure vapor sealed system components.

J. Aluminum Jacket:

1. Use continuous friction type joint to hold jacket in place, providing positive weatherproof seal over entire length of jacket.
2. Secure circumferential joints with preformed snap straps containing weatherproof sealant.
3. On exterior piping, apply coating over insulation and vapor barrier to prevent damage when aluminum fitting covers are installed.
4. Do not use screws or rivets to fasten fitting covers.
5. Install removable prefabricated aluminum covers on exterior flanges and unions.
6. Caulk and seal exterior joints to make watertight.

3.03 FIELD FINISHING

A. Apply coating of insulating cement where needed to obtain smooth and continuous appearance.

B. Where pipe labels or banding are specified, apply to finished insulation, not to pipe.

C. Painting Piping Insulation (Exposed to View):

1. Aluminum or color coded PVC jacketing does not require painting.
2. If insulated piping system is indicated to be painted in Section 40 27 00, Process Piping—General, piping shall receive the following:
   a. Prime coat in accordance with Section 09 90 00, Painting and Coating.

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b. Finished insulation (and not pipe) shall be painted in accordance with Section 09 90 00, Painting and Coating.

3.04 SUPPLEMENTS

A. The supplement listed below, following “End of Section,” is a part of this specification:

1. Service and Insulation Thickness Table.

END OF SECTION

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Service and Insulation Thickness								
					Finish Systems			
Service Type	**Pipe Legend**	**Thickness**	**Fluid Temperature (degrees F)***	**Insulation**	**Concealed from View**	**Indoors Exposed**	**Outdoors**	**Buried**
HG–Heating Systems (steam, condensate, and hot water)	HWR HWS	ASHRAE 90.1 or IECC whichever results in thickest insulation.	201 to 250	Type 2	None	F3 below 8' **[A: none above 8']** **[B: F2 above 8']** **[C: F1 above 8']**	F3	NA
DW–Domestic and Service Hot Water Systems.	HW	ASHRAE 90.1 or IECC whichever results in thickest insulation.	105 to 140	Type 1 (6" or less)	None	F3 below 8' **[A: none above 8']** **[B: F2 above 8']** **[C: F1 above 8']** **[D: F3 above 8']**	F3	NA
CS–Cooling Systems (Condensate control, chilled water, and refrigerant)	RD W1, W2	ASHRAE 90.1 or IECC whichever results in the thickest insulation.	40 to 60	Type 1 (6" or less)	None	F3 below 8' **[A: none above 8']** **[B: F2 above 8']** **[C: F3 above 8']**	F3	NA
HT–Piping requiring heat tracing.		Pipe Size: Insulation Thickness Inches:* 1/4-3: 1 3.5-10: 1.5 12-16: 2 18-24: 2.5		Type 2 Insulate and heat trace outside lines 1' above grade. Use Type 3 insulation from 1' above grade to frost depth.	None	F3 below 8' **[A: none above 8']** **[B: F2 above 8']** **[C: F3 above 8']**	F3	F4 on Type 3

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Service and Insulation Thickness								
					Finish Systems			
Service Type	**Pipe Legend**	**Thickness**	**Fluid Temperature (degrees F)***	**Insulation**	**Concealed from View**	**Indoors Exposed**	**Outdoors**	**Buried**
Liquid Oxygen	LOX	Pipe Size: Insulation Thickness Inches:* 3/4 & 1.5: 2.5 2 & 2.5: 3.0 3 & 4: 3.5 6 & 8: 4.0	Minus 300 F	Type 3	F4	F3	F3 & F4	F4
PE–Personnel Exposure		ASHRAE 90.1 or IECC whichever results in the thickest insulation	>140	Type 2 Minimum 1.5" thick	No insulation or finish	F3 below 8' **[A: none above 8'] [B: F2 above 8'] [C: F3 above 8']**	F3	NA

*Use these fluid temperatures unless otherwise noted in the Piping Schedule.
Inches*: Based upon insulation with glass fiber per ASTM C547, outdoors with 20 mph wind with 10 percent safety and no value assigned to cladding or air space at cladding. Matches the watts per foot in Section 40 05 33, Pipe Heat Tracing. 2012 IECC requires 1-inch minimum thickness.

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SECTION 40 80 01
PROCESS PIPING LEAKAGE TESTING

PART 1 GENERAL

1.01 SUBMITTALS

A. Informational Submittals:

1. Testing Plan:
   a. Submit prior to testing and include at least the information that follows.
      1) Testing dates.
      2) Piping systems and section(s) to be tested.
      3) Test type.
      4) Method of isolation.
      5) Calculation of maximum allowable leakage for piping section(s) to be tested.
2. Certifications of Calibration: Testing equipment.
3. Certified Test Report.

PART 2 PRODUCTS (NOT USED)

PART 3 EXECUTION

3.01 PREPARATION

A. Notify Engineer in writing 14 days in advance of testing. Perform testing in presence of Engineer.

B. Pressure Piping:

1. Install temporary thrust blocking or other restraint as necessary to protect adjacent piping or equipment and make taps in piping prior to testing.
2. Wait 5 days minimum after concrete thrust blocking is installed to perform pressure tests. If high-early strength cement is used for thrust blocking, wait may be reduced to 2 days.
3. Prior to test, remove or suitably isolate appurtenant instruments or devices that could be damaged by pressure testing.
4. Items that do not require testing include: tank overflows to atmospheric vented drains, tank atmospheric vents.
5. Test Pressure: As indicated on Piping Schedule, or as specified by equipment manufacturer for example, proprietary Carbon Dioxide generation and dissolution system.

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C. Test section may be filled with water and allowed to stand under low pressure prior to testing.

D. Gravity Piping:

1. Perform testing after service connections, manholes, and backfilling have been completed between stations to be tested.
2. Determine groundwater level at time of testing by exploratory holes or other method acceptable to Engineer.
3. Pipe 42 Inches Diameter and Larger: Joint testing device may be used to isolate and test individual joints.

3.02 HYDROSTATIC TEST FOR PRESSURE PIPING

A. Fluid: Clean water of such quality to prevent corrosion of materials in piping system.

B. Exposed Piping:

1. Perform testing on installed piping prior to application of insulation.
2. Maximum Filling Velocity: 0.25 foot per second, applied over full area of pipe.
3. Vent piping during filling. Open vents at high points of piping system or loosen flanges, using at least four bolts, or use equipment vents to purge air pockets.
4. Maintain hydrostatic test pressure continuously for 60 minutes, minimum, and for such additional time as necessary to conduct examinations for leakage.
5. Examine joints and connections for leakage.
6. Correct visible leakage and retest as specified.
7. Empty pipe of water prior to final cleaning or disinfection.

C. Buried Piping:

1. Test after backfilling has been completed.
2. Expel air from piping system during filling.
3. Apply and maintain specified test pressure with hydraulic force pump. Valve off piping system when test pressure is reached.
4. Maintain hydrostatic test pressure continuously for 2 hours minimum, reopening isolation valve only as necessary to restore test pressure.
5. Determine actual leakage by measuring quantity of water necessary to maintain specified test pressure for duration of test.

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6. Maximum Allowable Leakage:

$$L = \frac{SD(P)^{1/2}}{148{,}000}$$

where:

L = Allowable leakage, in gallons per hour.
S = Length of pipe tested, in feet.
D = Nominal diameter of pipe, in inches.
P = Test pressure during leakage test, in pounds per square inch.

7. Correct leakage greater than allowable, and retest as specified.

3.03 PNEUMATIC TEST FOR PRESSURE PIPING

A. Do not perform on:

1. PVC or CPVC pipe.
2. Piping larger than 18 inches.
3. Buried and other non-exposed piping.

B. Fluid: Oil-free, dry air.

C. Procedure:

1. Apply preliminary pneumatic test pressure of 25 psig maximum to piping system prior to final leak testing, to locate visible leaks. Apply soap bubble mixture to joints and connections; examine for leakage.
2. Correct visible leaks and repeat preliminary test until visible leaks are corrected.
3. Gradually increase pressure in system to half of specified test pressure. Thereafter, increase pressure in steps of approximately one-tenth of specified test pressure until required test pressure is reached.
4. Maintain pneumatic test pressure continuously for minimum of 10 minutes and for such additional time as necessary to conduct soap bubble examination for leakage.
5. Correct visible leakage and retest as specified.

D. Allowable Leakage: Piping system, exclusive of possible localized instances at pump or valve packing, shall show no visual evidence of leakage.

E. After testing and final cleaning, purge with nitrogen those lines that will carry flammable gases to assure no explosive mixtures will be present in system during filling process.

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3.04 HYDROSTATIC TEST FOR GRAVITY PIPING

A. Testing Equipment Accuracy: Plus or minus 1/2-gallon water leakage under specified conditions.

B. Maximum Allowable Leakage: 0.16 gallon(s) per hour per inch diameter per 100 feet. Include service connection footage in test section, subjected to minimum head specified.

C. **[A: Gravity Sanitary and Roof Drain Piping: Test with 15 feet of water to include highest horizontal vent in filled piping. Where vertical drain and vent systems exceed 15 feet in height, test systems in 15-foot vertical sections as piping is installed.]**

D. Exfiltration Test:

1. Hydrostatic Head:
   a. At least 6 feet above maximum estimated groundwater level in section being tested.
   b. No less than 6 feet above inside top of highest section of pipe in test section, including service connections.
2. Length of Pipe Tested: Limit length such that pressure on invert of lower end of section does not exceed 30 feet of water column.

E. Infiltration Test:

1. Groundwater Level: At least 6 feet above inside top of highest section of pipe in test section, including service connections.

F. Piping with groundwater infiltration rate greater than allowable leakage rate for exfiltration will be considered defective even if pipe previously passed a pressure test.

G. Defective Piping Sections: Replace, and retest as specified.

3.05 PNEUMATIC TEST FOR GRAVITY PIPING

A. Equipment:

1. Calibrate gauges with standardized test gauge provided by **[A: Engineer] [B:]** at start of each testing day. **[C: Engineer] [D:]** will witness calibration.
2. Install gauges, air piping manifolds, and valves at ground surface.
3. Provide pressure release device, such as rupture disc or pressure relief valve, to relieve pressure at 6 psi or less.
4. Restrain plugs used to close sewer lines to prevent blowoff.

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B. Procedure:

1. Require that no person enter manhole where pipe is under pressure.
2. Slowly introduce air into pipe section until internal air pressure reaches 4 psi greater than average back pressure of groundwater submerging pipe.
3. Allow 2 minutes minimum for air temperature to stabilize.

C. Allowable Leakage: Test section will be considered defective when time required for pressure to decrease from 3.5 psi to 2.5 psi greater than average back pressure of groundwater submerging pipe is less than that computed using values from following table:

Table 1*

A Pipe Diameter (Inches)	B Time per Foot up to Length in Col C (Seconds)	C Test Length (Feet)	D Test Time for any Length Between Col C & E (Min:Sec)	E Length at Which Time in Col F Applies (Feet)	F Time per Foot for Total Length (Seconds)
4	0.18	636	1:54	1,114	0.10
6	0.40	424	2:50	743	0.23
8	0.71	318	3:47	557	0.41
10	1.11	255	4:43	446	0.63
12	1.60	212	5:40	371	0.91
15	2.50	170	7:05	297	1.42
18	3.62	141	8:30	248	2.06
21	4.92	121	9:55	212	2.81
24	6.42	106	11:20	187	3.67

Example: 15-inch diameter pipe:
For 150 feet, T = 2.50 sec (Col B) x 150 ft = 375 sec = 6:15
For 250 feet, T = 7:05 (Col D)
For 500 feet, T = 1.42 sec (Col F) x 500 ft = 710 sec = 11:50

*Based on 0.003 cfm per square foot with a minimum significant loss of 2 cfm and a maximum loss of 3.5 cfm.

D. Piping with groundwater infiltration rate greater than allowable leakage rate for exfiltration will be considered defective even if pipe previously passed a pressure test.

E. Defective Piping Sections: Replace and retest as specified.

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3.06 CONTAINMENT PIPING LEAK TEST

A. Leak test containment piping by either of the following approaches:

1. Use 5 psig compressed air with soaped weld and fitting connections.
2. Hydrostatic leak test with the pressure loss not exceeding 0.2 psi over a minimum 15 minute duration. Use a pressure gauge with 0.1 psi resolution increments. Visually inspect all joints and connections for leaks.

B. Defective Piping Sections: Replace, and retest as specified.

3.07 FIELD QUALITY CONTROL

A. Test Report Documentation:

1. Test date.
2. Description and identification of piping tested.
3. Test fluid.
4. Test pressure.
5. Remarks, including:
   a. Leaks (type, location).
   b. Repair/replacement performed to remedy excessive leakage.
6. Signed by Contractor and Engineer to represent that test has been satisfactorily completed.

END OF SECTION

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SECTION 40 91 00
INSTRUMENTATION COMPONENTS

PART 1 GENERAL

1.01 WORK INCLUDED

A. This Section gives the requirements for furnishing instrumentation components.

1.02 RELATED SECTIONS

A. Related sections include the following:

1. Division 1, General Requirements.

1.03 SUBMITTALS

A. General: In accordance with Section 01 33 00, Submittal Procedures.

B. Informational Submittals:

1. Provide Manufacturer's O&M: In accordance with Section 01 78 23, Operation and Maintenance Data.
   a. Content for Each O&M Manual:
      1) Table of Contents.
      2) Manufacturer's standard product installation/O&M manuals.

1.04 DELIVERY, STORAGE, AND HANDLING

A. In accordance with Section 01 61 00, Common Product Requirements.

B. Packaged at the factory prior to shipment to protect each item from damage during shipment and storage. Containers protected against impact, abrasion, corrosion, discoloration and/or other damages. Clearly label contents of each container and provide information on the required storage conditions necessary for the equipment.

C. Notify CH2M HILL of the storage requirements and recommendations for the equipment prior to shipment.

D. Prior to shipment, include corrosive inhibitive vapor capsules in shipping containers, and related equipment as recommended by capsule manufacturer.

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PART 2 PRODUCTS

2.01 GENERAL

A. Provide components that are listed in the Instrument List in Article Supplements at the end of this Section. Specific component requirements are defined in the Instrument Data Sheets in Article Supplements at the end of this Section.

2.02 ELECTRICAL SURGE AND TRANSIENT PROTECTION

A. Equip control panels with surge-arresting devices to protect equipment from damage as a result of electrical transients induced in interconnecting lines from lightning discharges and nearby electrical devices.

1. Provide wiring, hardware, and protective devices meeting the Requirements of UL 1449 3rd Edition UL Standard for Safety for Surge.

B. Suppressor Locations:

1. At point of connection between an equipment item, including ac powered transmitters, and power supply conductor (direct-wired equipment).
2. On analog pairs at each end when the pair travels outside of building.
3. In other locations where equipment sensitivity to surges and transients requires additional protection beyond that inherent to design of equipment.

C. Suppressor Design:

1. Construction: First-stage, high-energy metal oxide varistor and second-stage, bipolar silicon avalanche device separated by series impedance; includes grounding wire, stud, or terminal.
2. Response: 5 nanoseconds maximum.
3. Recovery: Automatic.
4. Temperature Range: Minus 20 degrees C to plus 85 degrees C.
5. Enclosure Mounted: Encapsulated inflame retardant epoxy.

D. Suppressors on 120V ac Power Supply Connections:

1. Occurrences: Tested and rated for a minimum of 50 occurrences of IEEE C62.41 Category B test waveform.
2. First-Stage Clamping Voltage: 350 volts or less.
3. Second-Stage Clamping Voltage: 210 volts or less.

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4. Power Supplies for Continuous Operation:
    a. Four-Wire Transmitter or Receiver: Minimum 5 amps at 130V ac.
    b. All Other Applications: Minimum 30 amps at 130V ac.

E. Suppressors on Analog Signal Lines:

1. Test Waveform: Linear 8-microsecond rise in current from 0 amp to a peak current value followed by an exponential decay of current reaching one-half the peak value in 20 microseconds.
2. Surge Rating: Tested and rated for 50 occurrences of 2,000-amp peak test waveform.
    a. dc Clamping Voltage: 20 percent to 40 percent above operating voltage for circuit.
    b. dc Clamping Voltage Tolerance: Plus or minus 10 percent.
    c. Maximum Loop Resistance: 18 ohms per conductor.

F. Manufacturers and Products:

1. Analog Signals Lines: Emerson Edco PC-642 or SRA-64 series.
2. 120V ac Lines: Emerson Edco HSP-121.
3. 480-Volt, Three-Phase Power Supplies: Square D Model SDSA3650.
4. Field Mounted at Two-Wire Instruments:
    a. Encapsulated in stainless steel pipe nipples.
    b. Emerson Edco SS64 series.
5. Field Mounted at Four-Wire Instruments: With 120V ac outlet, ac circuit breaker, and 10-ohm resistor on signal line, all in enclosure.
    a. Enclosure:
        1) NEMA 4X Type 304 stainless steel with door.
        2) Maximum Size: 12 inches by 12 inches by 8 inches deep.
    b. Emerson Edco; SLAC series.

G. Grounding:

1. Coordinate surge suppressor grounding in field panels and field instrumentation with manufacturer’s requirements.
2. Provide control panels with an integral copper grounding bus for connection of suppressors and other required instrumentation.

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PART 3 EXECUTION

3.01 SUPPLEMENTS

A. The supplements listed below, following “End of Section,” are a part of this Specification:

1. Instrument List.
2. Instrument Data Sheets.
3. Specialty Analytical Measurement Components.

END OF SECTION

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INSTRUMENT LIST

DATASHEET	TAG NO	COMP_CODE	DESIGN DETAIL	FACILITY	ISA CODE	TAG LOOP NO	NUMBER	TAG_SUFFIX	P+ID NO	FUNCTION	SERVICE	FLUID	SUPPLY VOLTAGE	PANEL NO	PLC NO	CONSTRUCTION STATUS	NOTES
40 91 00BSup02_A07	AE-300-100-01	A07	PANEL	300	AE	100	01	A	080-I-0004_682853	PH	AA			ACP-300-01			MOUNT IN ACP-300-01 SEE 080-I-3012
40 91 00BSup02_A09	AE-300-100-01	A09	PANEL	300	AE	100	01	B	080-I-0004_682853	TURB	AA			ACP-300-01			
40 91 00BSup02_A09	AIT-300-100-01	A09	PANEL	300	AIT	100	01		080-I-0004_682853	PH/TURB	AA		120V	ACP-300-01			ORDER SC200 WITH TURBIDIMETER

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GENERAL	1	Tag Number	P&ID	AIT-280-100-06	080-I-0001
	2	Loop Title		Recycle Water Influent Turbidity	
	3				
	4	Area Classification		Non-Hazardous	
	5				
	6				
	7				
PROCESS CONDITIONS	8	Fluid		Raw Water	
	9	Pressure		7 - 10 PSI	
	10	Temperature		45 - 60 degF	
	11	Specific Gravity		1.0	
	12				
	13				
	14				
ELEMENT	15	Element Tag		AE-280-100-06	
	16	Element Type		Nephelometric	
	17	Range		0.001 to 100 NTU	
	18	Process Connection		1/4" Tubing	
	19	Drain		1/2" NPT	
	20	Mounting		Panel	
	21	Cable Length		6 ft	
	22				
	23	Ambient Temperature Limits		-4 degF to 140 degF	
	24	Process Temperature Limits		32 degF to 100 degF	
	25				
	26				
	27				
	28				
	29				
	30				
	31				
	32				
	33				
TRANSMITTER	34	Transmitter Tag		AIT-280-100-06	
	35	Mounting		Panel	
	36	Enclosure NEMA Rating		NEMA 4X	
	37	Power Supply	Voltage	4-Wire	120V AC (Hardwired)
	38	Output Signal	Quantity	4-20mAdc	2
	39	Communication Protocol			
CALIBRATION	40	Calibrated Range		0 - 50 NTU	
	41	Vendor Calibration		Field calibrate - Provide calibration certificate	
	42	Accuracy	Repeatability	2.0 Pct of Reading	1.0 Pct of Reading
	43				
OPTIONS	44	Tagging		Affix stainless steel tag with Tag Number	
	45	Sun Shield		No	
	46	Mounting Kit		No	
	47	Calibration Cylinder		Required	
	48	Standard for 20 NTU		Required	
PURCHASE	49	Manufacturer		HACH	
	50	Element/Transmitter Models		1720E (Element), SC200 TWO channel (Transmitter)	
	51	Element/Transmitter Ordering Part Number		2978100 (Kit to Order includes element and transmitter)	
	52	Stainless Steel Tag Ordering Part Number		891901	
	53				

A9	**Cutter Lateral WTP**
TURBIDITY ANALYZER AND TRANSMITTER	**AIT-280-100-06**

GENERAL	1	Tag Number	P&ID	AIT-280-100-06	080-I-0001
	2	Loop Title		Recycle Water Influent Turbidity	
	3				
	4	Area Classification		Non-Hazardous	
	5				
	6				
	7				
PROCESS CONDITIONS	8	Fluid		Raw Water	
	9	Pressure		7 - 10 PSI	
	10	Temperature		45 - 60 degF	
	11	Specific Gravity		1.0	
	12				
	13				
	14				
ELEMENT	15	Element Tag		AE-280-100-06	
	16	Element Type		Nephelometric	
	17	Range		0.001 to 100 NTU	
	18	Process Connection		1/4" Tubing	
	19	Drain		1/2" NPT	
	20	Mounting		Panel	
	21	Cable Length		6 ft	
	22				
	23	Ambient Temperature Limits		-4 degF to 140 degF	
	24	Process Temperature Limits		32 degF to 100 degF	
	25				
	26				
	27				
	28				
	29				
	30				
	31				
	32				
	33				
TRANSMITTER	34	Transmitter Tag		AIT-280-100-06	
	35	Mounting		Panel	
	36	Enclosure NEMA Rating		NEMA 4X	
	37	Power Supply	Voltage	4-Wire	120V AC (Hardwired)
	38	Output Signal	Quantity	4-20mAdc	2
	39	Communication Protocol			
CALIBRATION	40	Calibrated Range		0 - 50 NTU	
	41	Vendor Calibration		Field calibrate - Provide calibration certificate	
	42	Accuracy	Repeatability	2.0 Pct of Reading	1.0 Pct of Reading
	43				
OPTIONS	44	Tagging		Affix stainless steel tag with Tag Number	
	45	Sun Shield		No	
	46	Mounting Kit		No	
	47	Calibration Cylinder		Required	
	48	Standard for 20 NTU		Required	
PURCHASE	49	Manufacturer		HACH	
	50	Element/Transmitter Models		1720E (Element), SC200 single channel (Transmitter)	
	51	Element/Transmitter Ordering Part Number		2978100 (Kit to Order includes element and transmitter)	
	52	Stainless Steel Tag Ordering Part Number		891901	
	53				

A9	**Cutter Lateral WTP**
TURBIDITY ANALYZER AND TRANSMITTER	**AIT-280-100-06**

GENERAL	1	Tag Number	P&ID	AE-280-106-01B	080-I-0002
	2	Loop Title		Recycle Water Influent Turbidity	
	3				
	4	Area Classification		Non-Hazardous	
	5				
	6				
	7				
PROCESS CONDITIONS	8	Fluid		Raw Water	
	9	Pressure		7 - 10 PSI	
	10	Temperature		45 - 60 degF	
	11	Specific Gravity		1.0	
	12				
	13				
	14				
ELEMENT	15	Element Tag		AE-280-106-01B	
	16	Element Type		Nephelometric	
	17	Range		0.001 to 100 NTU	
	18	Process Connection		1/4" Tubing	
	19	Drain		1/2" NPT	
	20	Mounting		Panel	
	21	Cable Length		6 ft	
	22				
	23	Ambient Temperature Limits		-4 degF to 140 degF	
	24	Process Temperature Limits		32 degF to 100 degF	
	25				
	26				
	27				
	28				
	29				
	30				
	31				
	32				
	33				
TRANSMITTER	34	Transmitter Tag		AIT-280-106-01	
	35	Mounting		Panel	
	36	Enclosure NEMA Rating		NEMA 4X	
	37	Power Supply	Voltage	4-Wire	120V AC (Hardwired)
	38	Output Signal	Quantity	4-20mAdc	2
	39	Communication Protocol			
CALIBRATION	40	Calibrated Range		0 - 50 NTU	
	41	Vendor Calibration		Field calibrate - Provide calibration certificate	
	42	Accuracy	Repeatability	2.0 Pct of Reading	1.0 Pct of Reading
	43				
OPTIONS	44	Tagging		Affix stainless steel tag with Tag Number	
	45	Sun Shield		No	
	46	Mounting Kit		No	
	47	Calibration Cylinder		Required	
	48	Standard for 20 NTU		Required	
PURCHASE	49	Manufacturer		HACH	
	50	Element/Transmitter Models		1720E (Element), SC200 two channel (Transmitter)	
	51	Element/Transmitter Ordering Part Number		2978100 (Kit to Order includes element and transmitter)	
	52	Stainless Steel Tag Ordering Part Number		891901	
	53				

A9	**Cutter Lateral WTP**
TURBIDITY ANALYZER AND TRANSMITTER	**AE-280-106-01B**

GENERAL	1	Tag Number	P&ID	AE-280-106-01B	080-I-0002
	2	Loop Title		Recycle Water Influent Turbidity	
	3				
	4	Area Classification		Non-Hazardous	
	5				
	6				
	7				
PROCESS CONDITIONS	8	Fluid		Raw Water	
	9	Pressure		7 - 10 PSI	
	10	Temperature		45 - 60 degF	
	11	Specific Gravity		1.0	
	12				
	13				
	14				
ELEMENT	15	Element Tag		AE-280-106-01B	
	16	Element Type		Nephelometric	
	17	Range		0.001 to 100 NTU	
	18	Process Connection		1/4" Tubing	
	19	Drain		1/2" NPT	
	20	Mounting		Panel	
	21	Cable Length		6 ft	
	22				
	23	Ambient Temperature Limits		-4 degF to 140 degF	
	24	Process Temperature Limits		32 degF to 100 degF	
	25				
	26				
	27				
	28				
	29				
	30				
	31				
	32				
	33				
TRANSMITTER	34	Transmitter Tag		AIT-280-206-01	
	35	Mounting		Panel	
	36	Enclosure NEMA Rating		NEMA 4X	
	37	Power Supply	Voltage	4-Wire	120V AC (Hardwired)
	38	Output Signal	Quantity	4-20mAdc	2
	39	Communication Protocol			
CALIBRATION	40	Calibrated Range		0 - 50 NTU	
	41	Vendor Calibration		Field calibrate - Provide calibration certificate	
	42	Accuracy	Repeatability	2.0 Pct of Reading	1.0 Pct of Reading
	43				
OPTIONS	44	Tagging		Affix stainless steel tag with Tag Number	
	45	Sun Shield		No	
	46	Mounting Kit		No	
	47	Calibration Cylinder		Required	
	48	Standard for 20 NTU		Required	
PURCHASE	49	Manufacturer		HACH	
	50	Element/Transmitter Models		1720E (Element), SC200 two channel (Transmitter)	
	51	Element/Transmitter Ordering Part Number		2978100 (Kit to Order includes element and transmitter)	
	52	Stainless Steel Tag Ordering Part Number		891901	
	53				

A9	**Cutter Lateral WTP**
TURBIDITY ANALYZER AND TRANSMITTER	**AE-280-106-01B**

GENERAL	1	Tag Number	P&ID	AE-300-100-01B	080-I-0004
	2	Loop Title		Recycle Water Influent Turbidity	
	3				
	4	Area Classification		Non-Hazardous	
	5				
	6				
	7				
PROCESS CONDITIONS	8	Fluid		Raw Water	
	9	Pressure		7 - 10 PSI	
	10	Temperature		45 - 60 degF	
	11	Specific Gravity		1.0	
	12				
	13				
	14				
ELEMENT	15	Element Tag		AE-300-100-01B	
	16	Element Type		Nephelometric	
	17	Range		0.001 to 100 NTU	
	18	Process Connection		1/4" Tubing	
	19	Drain		1/2" NPT	
	20	Mounting		Panel	
	21	Cable Length		6 ft	
	22				
	23	Ambient Temperature Limits		-4 degF to 140 degF	
	24	Process Temperature Limits		32 degF to 100 degF	
	25				
	26				
	27				
	28				
	29				
	30				
	31				
	32				
	33				
TRANSMITTER	34	Transmitter Tag		AIT-300-100-01	
	35	Mounting		Panel	
	36	Enclosure NEMA Rating		NEMA 4X	
	37	Power Supply	Voltage	4-Wire	120V AC (Hardwired)
	38	Output Signal	Quantity	4-20mAdc	2
	39	Communication Protocol			
CALIBRATION	40	Calibrated Range		0 - 50 NTU	
	41	Vendor Calibration		Field calibrate - Provide calibration certificate	
	42	Accuracy	Repeatability	2.0 Pct of Reading	1.0 Pct of Reading
	43				
OPTIONS	44	Tagging		Affix stainless steel tag with Tag Number	
	45	Sun Shield		No	
	46	Mounting Kit		No	
	47	Calibration Cylinder		Required	
	48	Standard for 20 NTU		Required	
PURCHASE	49	Manufacturer		HACH	
	50	Element/Transmitter Models		1720E (Element), SC200 two channel (Transmitter)	
	51	Element/Transmitter Ordering Part Number		2978100 (Kit to Order includes element and transmitter)	
	52	Stainless Steel Tag Ordering Part Number		891901	
	53				

A9	**Cutter Lateral WTP**
TURBIDITY ANALYZER AND TRANSMITTER	**AE-300-100-01B**

GENERAL	1	Tag Number	P&ID	AIT-280-108-02	080-I-0002
	2	Loop Title		TSS To Sludge Transfer Station	
	3				
	4	Area Classification		Non-Classified	
	5	Line Number	Equipment Number		
	6	Line Size	Line Schedule		
	7				
PROCESS CONDITIONS	8	Fluid		Sludge	
	9	Pressure			
	10	Temperature			
	11	Specific Gravity	Viscosity	1.0	
	12	Conductivity	Density		
	13	Vapor Pressure	Critical Prssure		
	14				
ELEMENT	15	Element Tag		AE-280-108-02	
	16	Element Type		Insertion	
	17	Range		0 - 300 g/L	
	18	Process Connection		0.75 inch NPT	
	19	Body Material		AISI 316L	
	20	Mounting			
	21	Cable Length		49 Feet	
	22				
	23	Ambient Temperature Limits		-4 degF to 140 degF	
	24	Process Temperature Limits		23 degF to 120 degF	
SWITCH	25	Switch Type			
	26	Set Point			
	27	Set Point Direction			
	28	Deadband			
	29	Failure State			
	30	Contact Arrangement			
	31	Voltage	Contact Rating		
	32	Communication Protocol			
TRANSMITTER	33	Transmitter Tag			
	36	Mounting			
	37	Enclosure NEMA Rating			
	38	Power Supply	Voltage		120VAC
	39	Output Signal		4-20ma	
	40				
CALIBRATION	41	Calibrated Range		5 - 70 g/L	
	42	Vendor Calibration		Field calibrate - Provide calibration certificate	
	43	Accuracy	Repeatability	1.0 Pct of Full Scale	
	44				
OPTIONS	45	Tagging		Affix stainless steel tag with Tag Number	
	46	Sun Shield			
	47	Mounting Kit			
	48	Accessories			
	49				
PURCHASE	50	Manufacturer		Endress + Hauser	
	51	Element Model Number		CUS51D-AAD1B4	
	52	Transmitter Model Number		CM442-AAN2B6F011BAAZ1	
	53	Purchase Note		3 year warranty	
	54				

A35 **TOTAL SUSPENDED SOLIDS ANALYZER & TRANSMITTER**	**Cutter WTP** **AIT-280-108-02**

GENERAL	1	Tag Number	P&ID	LSH-380-100-01	080-I-0019
	2	Loop Title		Sulfuric Acid Storage Tank	
	3	Area Classification		Non-Hazardous	
	4				
	5	Line Number	Equipment Number		
	6	Line Size	Line Schedule		
	7				
PROCESS CONDITIONS	8	Fluid		Sulfuric Acid	
	9	Pressure		Atmospheric	
	10	Temperature			
	11	Specific Gravity	Viscosity	1.83	
	12	Conductivity	Density		
	13	Vapor Pressure	Critical Pressure		
	14				
ELEMENT	15	Element Type		Tuning Fork	
	16	Insertion Length		12"	
	17	Process Connection		2 inch - Class 150 ANSI Flange	
	18	Wetted Materials		Teflon	
	19	Power		120 vac	
	20	Enclosure NEMA Rating		NEMA 4X	
	21				
	22	Ambient Temperature Limits		-50 degF to 160 degF	
	23	Process Temperature Limits		-50 degF to 300 degF	
	24				
SWITCH	25	Switch Type			
	26	Set Point		TBD	
	27	Set Point Direction		Rising	
	28	Deadband			
	29	Failure State			
	30	Voltage			
	31	Contact Arrangement			
	32	Contact Rating			
	33	Communication Protocol			
	34				
	35				
	36				
	37				
	38				
	39				
	40				
CALIBRATION	41	Vendor Calibration		No	
	42				
	43				
	44	Accuracy	Repeatability	0.04 inches	0.004 inches
	45				
OPTIONS	46	Tagging		Affix paper tag with Tag Number	
	47				
	48				
	49				
PURCHASE	50	Manufacturer		Endress+Hauser	
	51	Model Number		FTL51C-AACLCLAE4AA	
	52	Purchase Note		1 year warranty	
	53				

L50 **LEVEL SWITCH - TUNING FORK**	**Cutter Lateral WTP** **As Noted**

GENERAL	1	Tag Number	P&ID	LSH-380-200-01	080-I-0020
	2	Loop Title		Ferric Chloride Storage Tank	
	3	Area Classification		Non-Hazardous	
	4				
	5	Line Number	Equipment Number		
	6	Line Size	Line Schedule		
	7				
PROCESS CONDITIONS	8	Fluid		FeCl	
	9	Pressure		Atmospheric	
	10	Temperature			
	11	Specific Gravity	Viscosity	1.43	
	12	Conductivity	Density		
	13	Vapor Pressure	Critical Pressure		
	14				
ELEMENT	15	Element Type		Tuning Fork	
	16	Insertion Length		12"	
	17	Process Connection		2 inch - Class 150 ANSI Flange	
	18	Wetted Materials		Teflon	
	19	Power		120 vac	
	20	Enclosure NEMA Rating		NEMA 4X	
	21				
	22	Ambient Temperature Limits		-50 degF to 160 degF	
	23	Process Temperature Limits		-50 degF to 300 degF	
	24				
SWITCH	25	Switch Type			
	26	Set Point		TBD	
	27	Set Point Direction		Rising	
	28	Deadband			
	29	Failure State			
	30	Voltage			
	31	Contact Arrangement			
	32	Contact Rating			
	33	Communication Protocol			
	34				
	35				
	36				
	37				
	38				
	39				
	40				
CALIBRATION	41	Vendor Calibration		No	
	42				
	43				
	44	Accuracy	Repeatability	0.04 inches	0.004 inches
	45				
OPTIONS	46	Tagging		Affix paper tag with Tag Number	
	47				
	48				
	49				
PURCHASE	50	Manufacturer		Endress+Hauser	
	51	Model Number		FTL51C-AACLCLAE4AA	
	52	Purchase Note		1 year warranty	
	53				

L50 **LEVEL SWITCH - TUNING FORK**	**Cutter Lateral WTP** **As Noted**

GENERAL	1	Tag Number	P&ID	LSH-380-300-01	080-I-0021
	2	Loop Title		SHC Storage Tank	
	3	Area Classification		Non-Hazardous	
	4				
	5	Line Number	Equipment Number		
	6	Line Size	Line Schedule		
	7				
PROCESS CONDITIONS	8	Fluid		Sodium Hypochlorite	
	9	Pressure		Atmospheric	
	10	Temperature			
	11	Specific Gravity	Viscosity	1.21	
	12	Conductivity	Density		
	13	Vapor Pressure	Critical Pressure		
	14				
ELEMENT	15	Element Type		Tuning Fork	
	16	Insertion Length		12"	
	17	Process Connection		2 inch - Class 150 ANSI Flange	
	18	Wetted Materials		Teflon	
	19	Power		120 vac	
	20	Enclosure NEMA Rating		NEMA 4X	
	21				
	22	Ambient Temperature Limits		-50 degF to 160 degF	
	23	Process Temperature Limits		-50 degF to 300 degF	
	24				
SWITCH	25	Switch Type			
	26	Set Point		TBD	
	27	Set Point Direction		Rising	
	28	Deadband			
	29	Failure State			
	30	Voltage			
	31	Contact Arrangement			
	32	Contact Rating			
	33	Communication Protocol			
	34				
	35				
	36				
	37				
	38				
	39				
	40				
CALIBRATION	41	Vendor Calibration		No	
	42				
	43				
	44	Accuracy	Repeatability	0.04 inches	0.004 inches
	45				
OPTIONS	46	Tagging		Affix paper tag with Tag Number	
	47				
	48				
	49				
PURCHASE	50	Manufacturer		Endress+Hauser	
	51	Model Number		FTL51C-AACLCLAE4AA	
	52	Purchase Note		1 year warranty	
	53				

L50 **LEVEL SWITCH - TUNING FORK**	**Cutter Lateral WTP** **As Noted**

GENERAL	1	Tag Number	P&ID	LSH-380-400-01	080-I-0022
	2	Loop Title		Sodium Hydroxide Storage Tank	
	3	Area Classification		Non-Hazardous	
	4				
	5	Line Number	Equipment Number		
	6	Line Size	Line Schedule		
	7				
PROCESS CONDITIONS	8	Fluid		NaOH	
	9	Pressure		Atmospheric	
	10	Temperature			
	11	Specific Gravity	Viscosity	1.54	
	12	Conductivity	Density		
	13	Vapor Pressure	Critical Pressure		
	14				
ELEMENT	15	Element Type		Tuning Fork	
	16	Insertion Length		12"	
	17	Process Connection		2 inch - Class 150 ANSI Flange	
	18	Wetted Materials		Teflon	
	19	Power		120 vac	
	20	Enclosure NEMA Rating		NEMA 4X	
	21				
	22	Ambient Temperature Limits		-50 degF to 160 degF	
	23	Process Temperature Limits		-50 degF to 300 degF	
	24				
SWITCH	25	Switch Type			
	26	Set Point		TBD	
	27	Set Point Direction		Rising	
	28	Deadband			
	29	Failure State			
	30	Voltage			
	31	Contact Arrangement			
	32	Contact Rating			
	33	Communication Protocol			
	34				
	35				
	36				
	37				
	38				
	39				
	40				
CALIBRATION	41	Vendor Calibration		No	
	42				
	43				
	44	Accuracy	Repeatability	0.04 inches	0.004 inches
	45				
OPTIONS	46	Tagging		Affix paper tag with Tag Number	
	47				
	48				
	49				
PURCHASE	50	Manufacturer		Endress+Hauser	
	51	Model Number		FTL51C-AACLCLAE4AA	
	52	Purchase Note		1 year warranty	
	53				

L50 **LEVEL SWITCH - TUNING FORK**	**Cutter Lateral WTP** **As Noted**

1	Tag Number	P&ID		
2	Loop Title			
3	Area Classification			
4				
5	Line Number	Equipment Number		
6	Line Size	Line Schedule		
7				
8	Fluid			
9	Pressure			
10	Temperature			
11	Specific Gravity	Viscosity		
12	Conductivity	Density		
13	Vapor Pressure	Critical Pressure		
14				
15	Element Type			
16	Insertion Length		Minimum 4.5 inches and a maximum of 120 inches.	
17	Process Connection			
18	Wetted Materials			
19				
20	Enclosure NEMA Rating			
21				
22	Ambient Temperature Limits			
23	Process Temperature Limits			
24				
25	Switch Type		Available with AC/DC relay output, switched analog output, or Profibus PA.	
26	Set Point			
27	Set Point Direction			
28	Deadband			
29	Failure State			
30	Voltage			
31	Contact Arrangement			
32	Contact Rating			
33	Communication Protocol			
34				
35				
36				
37				
38				
39				
40				
41	Vendor Calibration			
42				
43				
44	Accuracy	Repeatability		
45				
46	Tagging			
47				
48				
49				
50	Manufacturer			
51	Model Number			
52	Purchase Note			
53				

GENERAL	1	Tag Number	P&ID	FIT-300-001-04	080-I-0009
	2	Loop Title		Air Scour Air Flow	
	3	Area Classification		Non-Hazardous	
	4				
	5				
	6	Line Size		6 inch	
	7				
PROCESS CONDITIONS	8	Fluid		Air (Low Pressure)	
	9				
	10	Min Flow	Max Flow	0 cfm	300 cfm
	11	Pressure			
	12	Temperature			
	13	Specific Gravity			
	14				
	15				
	16				
	17	Vacuum Possibility		No	
	18				
ELEMENT	19	Element Tag		FE-300-001-04	
	20	Probe Length			
	21				
	22	Process Connection		6 inch Class 150 ANSI Flange	
	23	Probe Material		Alloy C-276/316L SST Support	
	24				
	25				
	26				
	27	Element Range			
	28				
	29	Process Temperature Limits		-40 degF to 257 degF	
	30				
TRANSMITTER	31	Transmitter Tag		FIT-300-001-04	
	32	Mounting		Wall	
	33	Enclosure NEMA Rating		NEMA 4X	
	34	Power Supply	Voltage	4-Wire	120 VAC
	35	Output Signal	Quantity	4-20 mA	2
	36	Communication Protocol		HART	
	37	Ambient Temperature Limits		-5 degF to 140 degF	
	38	Process Temperature Limits		-40 degF to 212 degF	
	39				
CALIBRATION	40	Calibrated Range			
	41	Vendor Calibration		Factory calibrate - Provide calibration certificate	
	42				
	43	Accuracy		1% Reading + 20 sfpm	
	44				
OPTIONS	45	Tagging		Affix stainless steel tag with Tag Number	
	46	Male Compression Fittings		Required	
	47	Teflon Insulated Cable		Required	
	48	Sun Shield			
PURCHASE	49	Manufacturer		Endress + Hauser	
	50	Model Number		65I	
	51	Compression Fittings Part Number			Quantity #
	52	Teflon Insulated Cable Part Number			Quantity #
	53				

F51	**Cutter Lateral WTP**
FLOW ELEMENT & TRANSMITTER, THERMO MASS FLOW	**November 9, 2017**
	FIT-300-001-04

GENERAL	1	Tag Number	P&ID	LIT-280-104-04	080-I-0002
	2	Loop Title		Flocc/Sed Basin 1	
	3	Area Classification		Non-Hazardous	
	4				
	5				
	6				
PROCESS CONDITIONS	7	Fluid		Raw Water	
	8				
	9				
	10				
	11				
	12				
	13				
ELEMENT	14	Element Tag		LE-280-104-04	
	15	Element Type		Ultrasonic Time of Flight	
	16	Inactive Length/Blocking Distance		1 foot	
	17				
	18	Wetted Materials		PVDF	
	19	Process Connection		1 inch NPT	
	20	Measurable Limits		27 feet	
	21	Beam Angle		6 Degrees	
	22	Cable Length		16 feet	
	23	Ambient Temperature Limits		-40 degF to 176 degF	
	24	Process Temperature Limits		-40 degF to 176 degF	
	25	Temperature Correction		Automatic/Integrated	
TRANSMITTER	26	Transmitter Tag		LE-300-100-04	
	27	Mounting		Remote	
	28	Enclosure NEMA Rating		NEMA 4X	
	29	Power Supply	Voltage	4-Wire	120VAC
	30	Output Signal		4-20 mA	
	31	Communication Protocol		HART	
	32	Range			
SWITCH	33	Switch Type			
	34	Set Point			
	35	Set Point Direction			
	36	Deadband			
	37	Failure State			
	38	Voltage			
	39	Contact Arrangement			
	40	Contact Rating			
	41				
CALIBRATION	42	Calibrated Range		0-20 feet	
	43	Zero Reference			
	44	Vendor Calibration		Factory calibrate - Provide calibration certificate	
	45	Accuracy		0.2 Pct of Span	
	46				
OPTIONS	47	Tagging		Affix stainless steel tag with Tag Number	
	48	Sun Shield			
	49				
PURCHASE	50	Manufacturer		Endress + Hauser	
	51	Model Number Sensor		FDU91F w/ FAX50 Flange	
	52	Model Number Transmitter		FMU90	
	53	Sun Shield Order Code			

L05	**Cutter Lateral WTP**
LEVEL TRANSMITTER - ULTRASONIC	**November 9, 2017**
	LIT-280-104-04

GENERAL	1	Tag Number	P&ID	LIT-280-204-04	080-I-0003
	2	Loop Title		Flocc/Sed Basin 1	
	3	Area Classification		Non-Hazardous	
	4				
	5				
	6				
PROCESS CONDITIONS	7	Fluid		Raw Water	
	8				
	9				
	10				
	11				
	12				
	13				
ELEMENT	14	Element Tag		LE-280-204-04	
	15	Element Type		Ultrasonic Time of Flight	
	16	Inactive Length/Blocking Distance		1 foot	
	17				
	18	Wetted Materials		PVDF	
	19	Process Connection		1 inch NPT	
	20	Measurable Limits		27 feet	
	21	Beam Angle		6 Degrees	
	22	Cable Length		16 feet	
	23	Ambient Temperature Limits		-40 degF to 176 degF	
	24	Process Temperature Limits		-40 degF to 176 degF	
	25	Temperature Correction		Automatic/Integrated	
TRANSMITTER	26	Transmitter Tag		LE-300-100-04	
	27	Mounting		Remote	
	28	Enclosure NEMA Rating		NEMA 4X	
	29	Power Supply	Voltage	4-Wire	120VAC
	30	Output Signal		4-20 mA	
	31	Communication Protocol		HART	
	32	Range			
SWITCH	33	Switch Type			
	34	Set Point			
	35	Set Point Direction			
	36	Deadband			
	37	Failure State			
	38	Voltage			
	39	Contact Arrangement			
	40	Contact Rating			
	41				
CALIBRATION	42	Calibrated Range		0-20 feet	
	43	Zero Reference			
	44	Vendor Calibration		Factory calibrate - Provide calibration certificate	
	45	Accuracy		0.2 Pct of Span	
	46				
OPTIONS	47	Tagging		Affix stainless steel tag with Tag Number	
	48	Sun Shield			
	49				
PURCHASE	50	Manufacturer		Endress + Hauser	
	51	Model Number Sensor		FDU91F w/ FAX50 Flange	
	52	Model Number Transmitter		FMU90	
	53	Sun Shield Order Code			

L05	**Cutter Lateral WTP**
LEVEL TRANSMITTER - ULTRASONIC	**November 9, 2017**
	LIT-280-204-04

GENERAL	1	Tag Number	P&ID	LIT-300-100-04	080-I-0004
	2	Loop Title		Backwash Waste Channel	
	3	Area Classification		Non-Hazardous	
	4				
	5				
	6				
PROCESS CONDITIONS	7	Fluid		Raw Water	
	8				
	9				
	10				
	11				
	12				
	13				
ELEMENT	14	Element Tag		LE-300-100-04	
	15	Element Type		Ultrasonic Time of Flight	
	16	Inactive Length/Blocking Distance		1 foot	
	17				
	18	Wetted Materials		PVDF	
	19	Process Connection		1 inch NPT	
	20	Measurable Limits		27 feet	
	21	Beam Angle		6 Degrees	
	22	Cable Length		16 feet	
	23	Ambient Temperature Limits		-40 degF to 176 degF	
	24	Process Temperature Limits		-40 degF to 176 degF	
	25	Temperature Correction		Automatic/Integrated	
TRANSMITTER	26	Transmitter Tag		LE-300-100-04	
	27	Mounting		Remote	
	28	Enclosure NEMA Rating		NEMA 4X	
	29	Power Supply	Voltage	4-Wire	120VAC
	30	Output Signal		4-20 mA	
	31	Communication Protocol		HART	
	32	Range			
SWITCH	33	Switch Type			
	34	Set Point			
	35	Set Point Direction			
	36	Deadband			
	37	Failure State			
	38	Voltage			
	39	Contact Arrangement			
	40	Contact Rating			
	41				
CALIBRATION	42	Calibrated Range		0-20 feet	
	43	Zero Reference			
	44	Vendor Calibration		Factory calibrate - Provide calibration certificate	
	45	Accuracy		0.2 Pct of Span	
	46				
OPTIONS	47	Tagging		Affix stainless steel tag with Tag Number	
	48	Sun Shield			
	49				
PURCHASE	50	Manufacturer		Endress + Hauser	
	51	Model Number Sensor		FDU91F w/ FAX50 Flange	
	52	Model Number Transmitter		FMU90	
	53	Sun Shield Order Code			

L05	**Cutter Lateral WTP**
LEVEL TRANSMITTER - ULTRASONIC	**November 9, 2017**
	LIT-300-100-04

GENERAL	1	Tag Number	P&ID	LIT-300-100-05	080-I-0004
	2	Loop Title		Filter Influent	
	3	Area Classification		Non-Hazardous	
	4				
	5				
	6				
PROCESS CONDITIONS	7	Fluid		Raw Water	
	8				
	9				
	10				
	11				
	12				
	13				
ELEMENT	14	Element Tag		LE-300-100-05	
	15	Element Type		Ultrasonic Time of Flight	
	16	Inactive Length/Blocking Distance		1 foot	
	17				
	18	Wetted Materials		PVDF	
	19	Process Connection		1 inch NPT	
	20	Measurable Limits		27 feet	
	21	Beam Angle		6 Degrees	
	22	Cable Length		16 feet	
	23	Ambient Temperature Limits		-40 degF to 176 degF	
	24	Process Temperature Limits		-40 degF to 176 degF	
	25	Temperature Correction		Automatic/Integrated	
TRANSMITTER	26	Transmitter Tag		LE-300-100-04	
	27	Mounting		Remote	
	28	Enclosure NEMA Rating		NEMA 4X	
	29	Power Supply	Voltage	4-Wire	120VAC
	30	Output Signal		4-20 mA	
	31	Communication Protocol		HART	
	32	Range			
SWITCH	33	Switch Type			
	34	Set Point			
	35	Set Point Direction			
	36	Deadband			
	37	Failure State			
	38	Voltage			
	39	Contact Arrangement			
	40	Contact Rating			
	41				
CALIBRATION	42	Calibrated Range		0-20 feet	
	43	Zero Reference			
	44	Vendor Calibration		Factory calibrate - Provide calibration certificate	
	45	Accuracy		0.2 Pct of Span	
	46				
OPTIONS	47	Tagging		Affix stainless steel tag with Tag Number	
	48	Sun Shield			
	49				
PURCHASE	50	Manufacturer		Endress + Hauser	
	51	Model Number Sensor		FDU91F w/ FAX50 Flange	
	52	Model Number Transmitter		FMU90	
	53	Sun Shield Order Code			

L05	**Cutter Lateral WTP**
LEVEL TRANSMITTER - ULTRASONIC	**November 9, 2017**
	LIT-300-100-05

GENERAL	1	Tag Number	P&ID	LIT-300-101-01	080-I-0005
	2	Loop Title		Filter 1 Level	
	3	Area Classification		Non-Hazardous	
	4				
	5				
	6				
PROCESS CONDITIONS	7	Fluid		Raw Water	
	8				
	9				
	10				
	11				
	12				
	13				
ELEMENT	14	Element Tag		LE-300-101-01	
	15	Element Type		Ultrasonic Time of Flight	
	16	Inactive Length/Blocking Distance		1 foot	
	17				
	18	Wetted Materials		PVDF	
	19	Process Connection		1 inch NPT	
	20	Measurable Limits		27 feet	
	21	Beam Angle		6 Degrees	
	22	Cable Length		16 feet	
	23	Ambient Temperature Limits		-40 degF to 176 degF	
	24	Process Temperature Limits		-40 degF to 176 degF	
	25	Temperature Correction		Automatic/Integrated	
TRANSMITTER	26	Transmitter Tag		LE-300-100-04	
	27	Mounting		Remote	
	28	Enclosure NEMA Rating		NEMA 4X	
	29	Power Supply	Voltage	4-Wire	120VAC
	30	Output Signal		4-20 mA	
	31	Communication Protocol		HART	
	32	Range			
SWITCH	33	Switch Type			
	34	Set Point			
	35	Set Point Direction			
	36	Deadband			
	37	Failure State			
	38	Voltage			
	39	Contact Arrangement			
	40	Contact Rating			
	41				
CALIBRATION	42	Calibrated Range		0-20 feet	
	43	Zero Reference			
	44	Vendor Calibration		Factory calibrate - Provide calibration certificate	
	45	Accuracy		0.2 Pct of Span	
	46				
OPTIONS	47	Tagging		Affix stainless steel tag with Tag Number	
	48	Sun Shield			
	49				
PURCHASE	50	Manufacturer		Endress + Hauser	
	51	Model Number Sensor		FDU91F w/ FAX50 Flange	
	52	Model Number Transmitter		FMU90	
	53	Sun Shield Order Code			

L05	**Cutter Lateral WTP**
LEVEL TRANSMITTER - ULTRASONIC	**November 9, 2017**
	LIT-300-101-01

GENERAL	1	Tag Number	P&ID	LIT-300-201-01	080-I-0006
	2	Loop Title		Filter 2 Level	
	3	Area Classification		Non-Hazardous	
	4				
	5				
	6				
PROCESS CONDITIONS	7	Fluid		Raw Water	
	8				
	9				
	10				
	11				
	12				
	13				
ELEMENT	14	Element Tag		LE-300-201-01	
	15	Element Type		Ultrasonic Time of Flight	
	16	Inactive Length/Blocking Distance		1 foot	
	17				
	18	Wetted Materials		PVDF	
	19	Process Connection		1 inch NPT	
	20	Measurable Limits		27 feet	
	21	Beam Angle		6 Degrees	
	22	Cable Length		16 feet	
	23	Ambient Temperature Limits		-40 degF to 176 degF	
	24	Process Temperature Limits		-40 degF to 176 degF	
	25	Temperature Correction		Automatic/Integrated	
TRANSMITTER	26	Transmitter Tag		LE-300-100-04	
	27	Mounting		Remote	
	28	Enclosure NEMA Rating		NEMA 4X	
	29	Power Supply	Voltage	4-Wire	120VAC
	30	Output Signal		4-20 mA	
	31	Communication Protocol		HART	
	32	Range			
SWITCH	33	Switch Type			
	34	Set Point			
	35	Set Point Direction			
	36	Deadband			
	37	Failure State			
	38	Voltage			
	39	Contact Arrangement			
	40	Contact Rating			
	41				
CALIBRATION	42	Calibrated Range		0-20 feet	
	43	Zero Reference			
	44	Vendor Calibration		Factory calibrate - Provide calibration certificate	
	45	Accuracy		0.2 Pct of Span	
	46				
OPTIONS	47	Tagging		Affix stainless steel tag with Tag Number	
	48	Sun Shield			
	49				
PURCHASE	50	Manufacturer		Endress + Hauser	
	51	Model Number Sensor		FDU91F w/ FAX50 Flange	
	52	Model Number Transmitter		FMU90	
	53	Sun Shield Order Code			

L05	**Cutter Lateral WTP**
LEVEL TRANSMITTER - ULTRASONIC	**November 9, 2017**
	LIT-300-201-01

GENERAL	1	Tag Number	P&ID	LIT-300-301-01	080-I-0007
	2	Loop Title		Filter 3 Level	
	3	Area Classification		Non-Hazardous	
	4				
	5				
	6				
PROCESS CONDITIONS	7	Fluid		Raw Water	
	8				
	9				
	10				
	11				
	12				
	13				
ELEMENT	14	Element Tag		LE-300-301-01	
	15	Element Type		Ultrasonic Time of Flight	
	16	Inactive Length/Blocking Distance		1 foot	
	17				
	18	Wetted Materials		PVDF	
	19	Process Connection		1 inch NPT	
	20	Measurable Limits		27 feet	
	21	Beam Angle		6 Degrees	
	22	Cable Length		16 feet	
	23	Ambient Temperature Limits		-40 degF to 176 degF	
	24	Process Temperature Limits		-40 degF to 176 degF	
	25	Temperature Correction		Automatic/Integrated	
TRANSMITTER	26	Transmitter Tag		LE-300-100-04	
	27	Mounting		Remote	
	28	Enclosure NEMA Rating		NEMA 4X	
	29	Power Supply	Voltage	4-Wire	120VAC
	30	Output Signal		4-20 mA	
	31	Communication Protocol		HART	
	32	Range			
SWITCH	33	Switch Type			
	34	Set Point			
	35	Set Point Direction			
	36	Deadband			
	37	Failure State			
	38	Voltage			
	39	Contact Arrangement			
	40	Contact Rating			
	41				
CALIBRATION	42	Calibrated Range		0-20 feet	
	43	Zero Reference			
	44	Vendor Calibration		Factory calibrate - Provide calibration certificate	
	45	Accuracy		0.2 Pct of Span	
	46				
OPTIONS	47	Tagging		Affix stainless steel tag with Tag Number	
	48	Sun Shield			
	49				
PURCHASE	50	Manufacturer		Endress + Hauser	
	51	Model Number Sensor		FDU91F w/ FAX50 Flange	
	52	Model Number Transmitter		FMU90	
	53	Sun Shield Order Code			

L05	**Cutter Lateral WTP**
LEVEL TRANSMITTER - ULTRASONIC	**November 9, 2017**
	LIT-300-301-01

GENERAL	1	Tag Number	P&ID	LIT-300-401-01	080-I-0008
	2	Loop Title		Filter 4 Level	
	3	Area Classification		Non-Hazardous	
	4				
	5				
	6				
PROCESS CONDITIONS	7	Fluid		Raw Water	
	8				
	9				
	10				
	11				
	12				
	13				
ELEMENT	14	Element Tag		LE-400-301-01	
	15	Element Type		Ultrasonic Time of Flight	
	16	Inactive Length/Blocking Distance		1 foot	
	17				
	18	Wetted Materials		PVDF	
	19	Process Connection		1 inch NPT	
	20	Measurable Limits		27 feet	
	21	Beam Angle		6 Degrees	
	22	Cable Length		16 feet	
	23	Ambient Temperature Limits		-40 degF to 176 degF	
	24	Process Temperature Limits		-40 degF to 176 degF	
	25	Temperature Correction		Automatic/Integrated	
TRANSMITTER	26	Transmitter Tag		LE-300-100-04	
	27	Mounting		Remote	
	28	Enclosure NEMA Rating		NEMA 4X	
	29	Power Supply	Voltage	4-Wire	120VAC
	30	Output Signal		4-20 mA	
	31	Communication Protocol		HART	
	32	Range			
SWITCH	33	Switch Type			
	34	Set Point			
	35	Set Point Direction			
	36	Deadband			
	37	Failure State			
	38	Voltage			
	39	Contact Arrangement			
	40	Contact Rating			
	41				
CALIBRATION	42	Calibrated Range		0-20 feet	
	43	Zero Reference			
	44	Vendor Calibration		Factory calibrate - Provide calibration certificate	
	45	Accuracy		0.2 Pct of Span	
	46				
OPTIONS	47	Tagging		Affix stainless steel tag with Tag Number	
	48	Sun Shield			
	49				
PURCHASE	50	Manufacturer		Endress + Hauser	
	51	Model Number Sensor		FDU91F w/ FAX50 Flange	
	52	Model Number Transmitter		FMU90	
	53	Sun Shield Order Code			

L05	**Cutter Lateral WTP**
LEVEL TRANSMITTER - ULTRASONIC	**November 9, 2017**
	LIT-300-401-01

GENERAL	1	Tag Number	P&ID	LIT-500-101-01	080-I-0013
	2	Loop Title		Finished Water Seal Weir	
	3	Area Classification		Non-Hazardous	
	4				
	5				
	6				
PROCESS CONDITIONS	7	Fluid		Finished Water	
	8				
	9				
	10				
	11				
	12				
	13				
ELEMENT	14	Element Tag		LE-500-101-01	
	15	Element Type		Ultrasonic Time of Flight	
	16	Inactive Length/Blocking Distance		1 foot	
	17				
	18	Wetted Materials		PVDF	
	19	Process Connection		1 inch NPT	
	20	Measurable Limits		27 feet	
	21	Beam Angle		6 Degrees	
	22	Cable Length		16 feet	
	23	Ambient Temperature Limits		-40 degF to 176 degF	
	24	Process Temperature Limits		-40 degF to 176 degF	
	25	Temperature Correction		Automatic/Integrated	
TRANSMITTER	26	Transmitter Tag		LE-300-100-04	
	27	Mounting		Remote	
	28	Enclosure NEMA Rating		NEMA 4X	
	29	Power Supply	Voltage	4-Wire	120VAC
	30	Output Signal		4-20 mA	
	31	Communication Protocol		HART	
	32	Range			
SWITCH	33	Switch Type			
	34	Set Point			
	35	Set Point Direction			
	36	Deadband			
	37	Failure State			
	38	Voltage			
	39	Contact Arrangement			
	40	Contact Rating			
	41				
CALIBRATION	42	Calibrated Range		0-20 feet	
	43	Zero Reference			
	44	Vendor Calibration		Factory calibrate - Provide calibration certificate	
	45	Accuracy		0.2 Pct of Span	
	46				
OPTIONS	47	Tagging		Affix stainless steel tag with Tag Number	
	48	Sun Shield			
	49				
PURCHASE	50	Manufacturer		Endress + Hauser	
	51	Model Number Sensor		FDU91F w/ FAX50 Flange	
	52	Model Number Transmitter		FMU90	
	53	Sun Shield Order Code			

L05	**Cutter Lateral WTP**
LEVEL TRANSMITTER - ULTRASONIC	**November 9, 2017**
	LIT-500-101-01

GENERAL	1	Tag Number	P&ID	LIT-360-101-01	080-I-0014
	2	Loop Title		Finished Water Wet Well 1	
	3	Area Classification		Non-Hazardous	
	4				
	5				
	6				
PROCESS CONDITIONS	7	Fluid		Finished Water	
	8				
	9				
	10				
	11				
	12				
	13				
ELEMENT	14	Element Tag		LE-360-101-01	
	15	Element Type		Ultrasonic Time of Flight	
	16	Inactive Length/Blocking Distance		1 foot	
	17				
	18	Wetted Materials		PVDF	
	19	Process Connection		1 inch NPT	
	20	Measurable Limits		27 feet	
	21	Beam Angle		6 Degrees	
	22	Cable Length		16 feet	
	23	Ambient Temperature Limits		-40 degF to 176 degF	
	24	Process Temperature Limits		-40 degF to 176 degF	
	25	Temperature Correction		Automatic/Integrated	
TRANSMITTER	26	Transmitter Tag		LE-300-100-04	
	27	Mounting		Remote	
	28	Enclosure NEMA Rating		NEMA 4X	
	29	Power Supply	Voltage	4-Wire	120VAC
	30	Output Signal		4-20 mA	
	31	Communication Protocol		HART	
	32	Range			
SWITCH	33	Switch Type			
	34	Set Point			
	35	Set Point Direction			
	36	Deadband			
	37	Failure State			
	38	Voltage			
	39	Contact Arrangement			
	40	Contact Rating			
	41				
CALIBRATION	42	Calibrated Range		0-20 feet	
	43	Zero Reference			
	44	Vendor Calibration		Factory calibrate - Provide calibration certificate	
	45	Accuracy		0.2 Pct of Span	
	46				
OPTIONS	47	Tagging		Affix stainless steel tag with Tag Number	
	48	Sun Shield			
	49				
PURCHASE	50	Manufacturer		Endress + Hauser	
	51	Model Number Sensor		FDU91F w/ FAX50 Flange	
	52	Model Number Transmitter		FMU90	
	53	Sun Shield Order Code			

L05	**Cutter Lateral WTP**
LEVEL TRANSMITTER - ULTRASONIC	**November 9, 2017**
	LIT-360-101-01

GENERAL	1	Tag Number	P&ID	LIT-360-201-01	080-I-0014
	2	Loop Title		Finished Water Wet Well 1	
	3	Area Classification		Non-Hazardous	
	4				
	5				
	6				
PROCESS CONDITIONS	7	Fluid		Finished Water	
	8				
	9				
	10				
	11				
	12				
	13				
ELEMENT	14	Element Tag		LE-360-201-01	
	15	Element Type		Ultrasonic Time of Flight	
	16	Inactive Length/Blocking Distance		1 foot	
	17				
	18	Wetted Materials		PVDF	
	19	Process Connection		1 inch NPT	
	20	Measurable Limits		27 feet	
	21	Beam Angle		6 Degrees	
	22	Cable Length		16 feet	
	23	Ambient Temperature Limits		-40 degF to 176 degF	
	24	Process Temperature Limits		-40 degF to 176 degF	
	25	Temperature Correction		Automatic/Integrated	
TRANSMITTER	26	Transmitter Tag		LE-300-100-04	
	27	Mounting		Remote	
	28	Enclosure NEMA Rating		NEMA 4X	
	29	Power Supply	Voltage	4-Wire	120VAC
	30	Output Signal		4-20 mA	
	31	Communication Protocol		HART	
	32	Range			
SWITCH	33	Switch Type			
	34	Set Point			
	35	Set Point Direction			
	36	Deadband			
	37	Failure State			
	38	Voltage			
	39	Contact Arrangement			
	40	Contact Rating			
	41				
CALIBRATION	42	Calibrated Range		0-20 feet	
	43	Zero Reference			
	44	Vendor Calibration		Factory calibrate - Provide calibration certificate	
	45	Accuracy		0.2 Pct of Span	
	46				
OPTIONS	47	Tagging		Affix stainless steel tag with Tag Number	
	48	Sun Shield			
	49				
PURCHASE	50	Manufacturer		Endress + Hauser	
	51	Model Number Sensor		FDU91F w/ FAX50 Flange	
	52	Model Number Transmitter		FMU90	
	53	Sun Shield Order Code			

L05	**Cutter Lateral WTP**
LEVEL TRANSMITTER - ULTRASONIC	**November 9, 2017**
	LIT-360-201-01

GENERAL	1	Tag Number	P&ID	LIT-420-100-01	080-I-0016
	2	Loop Title		BWW Pond Influent Box Level	
	3	Area Classification		Non-Hazardous	
	4				
	5				
	6				
PROCESS CONDITIONS	7	Fluid		Backwash Waste Water	
	8				
	9				
	10				
	11				
	12				
	13				
ELEMENT	14	Element Tag		LE-420-100-01	
	15	Element Type		Ultrasonic Time of Flight	
	16	Inactive Length/Blocking Distance		1 foot	
	17				
	18	Wetted Materials		PVDF	
	19	Process Connection		1 inch NPT	
	20	Measurable Limits		27 feet	
	21	Beam Angle		6 Degrees	
	22	Cable Length		16 feet	
	23	Ambient Temperature Limits		-40 degF to 176 degF	
	24	Process Temperature Limits		-40 degF to 176 degF	
	25	Temperature Correction		Automatic/Integrated	
TRANSMITTER	26	Transmitter Tag		LE-300-100-04	
	27	Mounting		Remote	
	28	Enclosure NEMA Rating		NEMA 4X	
	29	Power Supply	Voltage	4-Wire	120VAC
	30	Output Signal		4-20 mA	
	31	Communication Protocol		HART	
	32	Range			
SWITCH	33	Switch Type			
	34	Set Point			
	35	Set Point Direction			
	36	Deadband			
	37	Failure State			
	38	Voltage			
	39	Contact Arrangement			
	40	Contact Rating			
	41				
CALIBRATION	42	Calibrated Range		0-20 feet	
	43	Zero Reference			
	44	Vendor Calibration		Factory calibrate - Provide calibration certificate	
	45	Accuracy		0.2 Pct of Span	
	46				
OPTIONS	47	Tagging		Affix stainless steel tag with Tag Number	
	48	Sun Shield			
	49				
PURCHASE	50	Manufacturer		Endress + Hauser	
	51	Model Number Sensor		FDU91F w/ FAX50 Flange	
	52	Model Number Transmitter		FMU90	
	53	Sun Shield Order Code			

L05	**Cutter Lateral WTP**
LEVEL TRANSMITTER - ULTRASONIC	**November 9, 2017**
	LIT-420-100-01

GENERAL	1	Tag Number	P&ID	LIT-420-100-02	080-I-0016
	2	Loop Title		Sludge Transfer Station level	
	3	Area Classification		Non-Hazardous	
	4				
	5				
	6				
PROCESS CONDITIONS	7	Fluid		Backwash Waste Water	
	8				
	9				
	10				
	11				
	12				
	13				
ELEMENT	14	Element Tag		LE-420-100-02	
	15	Element Type		Ultrasonic Time of Flight	
	16	Inactive Length/Blocking Distance		1 foot	
	17				
	18	Wetted Materials		PVDF	
	19	Process Connection		1 inch NPT	
	20	Measurable Limits		27 feet	
	21	Beam Angle		6 Degrees	
	22	Cable Length		16 feet	
	23	Ambient Temperature Limits		-40 degF to 176 degF	
	24	Process Temperature Limits		-40 degF to 176 degF	
	25	Temperature Correction		Automatic/Integrated	
TRANSMITTER	26	Transmitter Tag		LE-300-100-04	
	27	Mounting		Remote	
	28	Enclosure NEMA Rating		NEMA 4X	
	29	Power Supply	Voltage	4-Wire	120VAC
	30	Output Signal		4-20 mA	
	31	Communication Protocol		HART	
	32	Range			
SWITCH	33	Switch Type			
	34	Set Point			
	35	Set Point Direction			
	36	Deadband			
	37	Failure State			
	38	Voltage			
	39	Contact Arrangement			
	40	Contact Rating			
	41				
CALIBRATION	42	Calibrated Range		0-20 feet	
	43	Zero Reference			
	44	Vendor Calibration		Factory calibrate - Provide calibration certificate	
	45	Accuracy		0.2 Pct of Span	
	46				
OPTIONS	47	Tagging		Affix stainless steel tag with Tag Number	
	48	Sun Shield			
	49				
PURCHASE	50	Manufacturer		Endress + Hauser	
	51	Model Number Sensor		FDU91F w/ FAX50 Flange	
	52	Model Number Transmitter		FMU90	
	53	Sun Shield Order Code			

L05	**Cutter Lateral WTP**
LEVEL TRANSMITTER - ULTRASONIC	**November 9, 2017**
	LIT-420-100-02

GENERAL	1	Tag Number	P&ID	LIT-460-100-00	080-I-0017
	2	Loop Title		Decant Pump Station	
	3	Area Classification		Non-Hazardous	
	4				
	5				
	6				
PROCESS CONDITIONS	7	Fluid		Decant Water	
	8				
	9				
	10				
	11				
	12				
	13				
ELEMENT	14	Element Tag		LE-460-100-00	
	15	Element Type		Ultrasonic Time of Flight	
	16	Inactive Length/Blocking Distance		1 foot	
	17				
	18	Wetted Materials		PVDF	
	19	Process Connection		1 inch NPT	
	20	Measurable Limits		27 feet	
	21	Beam Angle		6 Degrees	
	22	Cable Length		16 feet	
	23	Ambient Temperature Limits		-40 degF to 176 degF	
	24	Process Temperature Limits		-40 degF to 176 degF	
	25	Temperature Correction		Automatic/Integrated	
TRANSMITTER	26	Transmitter Tag		LE-300-100-04	
	27	Mounting		Remote	
	28	Enclosure NEMA Rating		NEMA 4X	
	29	Power Supply	Voltage	4-Wire	120VAC
	30	Output Signal		4-20 mA	
	31	Communication Protocol		HART	
	32	Range			
SWITCH	33	Switch Type			
	34	Set Point			
	35	Set Point Direction			
	36	Deadband			
	37	Failure State			
	38	Voltage			
	39	Contact Arrangement			
	40	Contact Rating			
	41				
CALIBRATION	42	Calibrated Range		0-20 feet	
	43	Zero Reference			
	44	Vendor Calibration		Factory calibrate - Provide calibration certificate	
	45	Accuracy		0.2 Pct of Span	
	46				
OPTIONS	47	Tagging		Affix stainless steel tag with Tag Number	
	48	Sun Shield			
	49				
PURCHASE	50	Manufacturer		Endress + Hauser	
	51	Model Number Sensor		FDU91F w/ FAX50 Flange	
	52	Model Number Transmitter		FMU90	
	53	Sun Shield Order Code			

L05	**Cutter Lateral WTP**
LEVEL TRANSMITTER - ULTRASONIC	**November 9, 2017**
	LIT-460-100-00

GENERAL	1	Tag Number	P&ID	LIT-440-101-00	080-I-0017
	2	Loop Title		Solids Drying Pond 1	
	3	Area Classification		Non-Hazardous	
	4				
	5				
	6				
PROCESS CONDITIONS	7	Fluid		Decant Water	
	8				
	9				
	10				
	11				
	12				
	13				
ELEMENT	14	Element Tag		LE-440-101-00	
	15	Element Type		Ultrasonic Time of Flight	
	16	Inactive Length/Blocking Distance		1 foot	
	17				
	18	Wetted Materials		PVDF	
	19	Process Connection		1 inch NPT	
	20	Measurable Limits		27 feet	
	21	Beam Angle		6 Degrees	
	22	Cable Length		16 feet	
	23	Ambient Temperature Limits		-40 degF to 176 degF	
	24	Process Temperature Limits		-40 degF to 176 degF	
	25	Temperature Correction		Automatic/Integrated	
TRANSMITTER	26	Transmitter Tag		LE-300-100-04	
	27	Mounting		Remote	
	28	Enclosure NEMA Rating		NEMA 4X	
	29	Power Supply	Voltage	4-Wire	120VAC
	30	Output Signal		4-20 mA	
	31	Communication Protocol		HART	
	32	Range			
SWITCH	33	Switch Type			
	34	Set Point			
	35	Set Point Direction			
	36	Deadband			
	37	Failure State			
	38	Voltage			
	39	Contact Arrangement			
	40	Contact Rating			
	41				
CALIBRATION	42	Calibrated Range		0-20 feet	
	43	Zero Reference			
	44	Vendor Calibration		Factory calibrate - Provide calibration certificate	
	45	Accuracy		0.2 Pct of Span	
	46				
OPTIONS	47	Tagging		Affix stainless steel tag with Tag Number	
	48	Sun Shield			
	49				
PURCHASE	50	Manufacturer		Endress + Hauser	
	51	Model Number Sensor		FDU91F w/ FAX50 Flange	
	52	Model Number Transmitter		FMU90	
	53	Sun Shield Order Code			

L05	**Cutter Lateral WTP**
LEVEL TRANSMITTER - ULTRASONIC	**November 9, 2017**
	LIT-440-101-00

GENERAL	1	Tag Number	P&ID	LIT-440-201-00	080-I-0017
	2	Loop Title		Solids Drying Pond 2	
	3	Area Classification		Non-Hazardous	
	4				
	5				
	6				
PROCESS CONDITIONS	7	Fluid		Decant Water	
	8				
	9				
	10				
	11				
	12				
	13				
ELEMENT	14	Element Tag		LE-440-201-00	
	15	Element Type		Ultrasonic Time of Flight	
	16	Inactive Length/Blocking Distance		1 foot	
	17				
	18	Wetted Materials		PVDF	
	19	Process Connection		1 inch NPT	
	20	Measurable Limits		27 feet	
	21	Beam Angle		6 Degrees	
	22	Cable Length		16 feet	
	23	Ambient Temperature Limits		-40 degF to 176 degF	
	24	Process Temperature Limits		-40 degF to 176 degF	
	25	Temperature Correction		Automatic/Integrated	
TRANSMITTER	26	Transmitter Tag		LE-300-100-04	
	27	Mounting		Remote	
	28	Enclosure NEMA Rating		NEMA 4X	
	29	Power Supply	Voltage	4-Wire	120VAC
	30	Output Signal		4-20 mA	
	31	Communication Protocol		HART	
	32	Range			
SWITCH	33	Switch Type			
	34	Set Point			
	35	Set Point Direction			
	36	Deadband			
	37	Failure State			
	38	Voltage			
	39	Contact Arrangement			
	40	Contact Rating			
	41				
CALIBRATION	42	Calibrated Range		0-20 feet	
	43	Zero Reference			
	44	Vendor Calibration		Factory calibrate - Provide calibration certificate	
	45	Accuracy		0.2 Pct of Span	
	46				
OPTIONS	47	Tagging		Affix stainless steel tag with Tag Number	
	48	Sun Shield			
	49				
PURCHASE	50	Manufacturer		Endress + Hauser	
	51	Model Number Sensor		FDU91F w/ FAX50 Flange	
	52	Model Number Transmitter		FMU90	
	53	Sun Shield Order Code			

L05	**Cutter Lateral WTP**
LEVEL TRANSMITTER - ULTRASONIC	**November 9, 2017**
	LIT-440-201-00

GENERAL	1	Tag Number	P&ID	LSH-380-500-05	080-I-0023
	2	Loop Title		Ionic Cationic Sump Switch	
	3	Area Classification		Non-Hazardous	
	4				
	5				
	6				
	7				
PROCESS CONDITIONS	8	Fluid		Polymer	
	9	Pressure		Atmospheric	
	10	Temperature		45 - 60 degF	
	11	Specific Gravity		1.0	
	12				
	13				
	14				
ELEMENT	15	Element Type		Float, Mercury Free	
	16	Cable Length		15 ft	
	17	Wetted Materials		Polypropylene	
	18				
	19				
	20				
	21				
	22	Ambient Temperature Limits		140 degF	
	23	Process Temperature Limits			
	24				
SWITCH	25	Switch Type		Relay Output	
	26	Set Point		4.5 ft	
	27	Set Point Direction		Rising	
	28	Deadband			
	29	Failure State		Switch breaks contact when de-actuated at low level	
	30	Voltage		120 VAC	
	31	Contact Arrangement			
	32	Contact Rating		7 Amps	
	33	Communication Protocol			
	34				
CALIBRATION	35	Vendor Calibration		Factory calibrate - Provide calibration certificate	
	36				
	37				
	38				
	39				
OPTIONS	40	Tagging		Affix stainless steel tag with Tag Number	
	41	Pipe Mounting Clamp		Yes	
	42	Cable/Weight Suspension Kit		No	
	43	Internal Weight Suspension Kit		No	
	44				
	45				
	46				
	47				
	48				
	49				
PURCHASE	50	Manufacturer		Contegra	
	51	Model Number		FS-90	
	52				
	53				

L08	**Cutter Lateral WTP**
LEVEL SWITCH - FLOAT	**November 9, 2017**
	LSH-380-500-05

GENERAL	1	Tag Number	P&ID	LSH-380-700-01	080-I-0027
	2	Loop Title		Sulfuric Acid	
	3	Area Classification		Non-Hazardous	
	4				
	5				
	6				
	7				
PROCESS CONDITIONS	8	Fluid		Sulfuric Acid	
	9	Pressure		Atmospheric	
	10	Temperature		45 - 60 degF	
	11	Specific Gravity		1.0	
	12				
	13				
	14				
ELEMENT	15	Element Type		Float, Mercury Free	
	16	Cable Length		15 ft	
	17	Wetted Materials		Polypropylene	
	18				
	19				
	20				
	21				
	22	Ambient Temperature Limits		140 degF	
	23	Process Temperature Limits			
	24				
SWITCH	25	Switch Type		Relay Output	
	26	Set Point		4.5 ft	
	27	Set Point Direction		Rising	
	28	Deadband			
	29	Failure State		Switch breaks contact when de-actuated at low level	
	30	Voltage		120 VAC	
	31	Contact Arrangement			
	32	Contact Rating		7 Amps	
	33	Communication Protocol			
	34				
CALIBRATION	35	Vendor Calibration		Factory calibrate - Provide calibration certificate	
	36				
	37				
	38				
	39				
OPTIONS	40	Tagging		Affix stainless steel tag with Tag Number	
	41	Pipe Mounting Clamp		Yes	
	42	Cable/Weight Suspension Kit		No	
	43	Internal Weight Suspension Kit		No	
	44				
	45				
	46				
	47				
	48				
	49				
PURCHASE	50	Manufacturer		Contegra	
	51	Model Number		FS-90	
	52				
	53				

L08	**Cutter Lateral WTP**
LEVEL SWITCH - FLOAT	**November 9, 2017**
	LSH-380-700-01

GENERAL	1	Tag Number	P&ID	AE-280-100-02	080-I-0001
	2	Loop Title		Recycle Water Ph	
	3				
	4	Area Classification		Non-Hazardous	
	5	Line Number	Equipment Number		
	6	Line Size	Line Schedule	N/A	
	7				
PROCESS CONDITIONS	8	Fluid		Raw Water	
	9	Pressure			
	10	Temperature			
	11	Specific Gravity	Viscosity		
	12	Conductivity	Density		
	13	Vapor Pressure	Critical Pressure		
	14				
Element	15	Element Tag		AE-280-100-02	
	16	Element Type		Convertible	
	17	Element Measurement		pH/ORP Combination	
	18	Range		2.5-12.5 pH / -1000-1000 mV	
	19	Process Connection		0.75 inch NPT	
	20	Body Material		Ryton	
	21	Electrode Material		Glass	
	22	Cable Length		10 feet	
	23	Ambient Temperature Limits			
	24	Process Temperature Limits			
SWITCH	25	Switch Type			
	26	Set Point			
	27	Set Point Direction			
	28	Deadband			
	29	Failure State			
	30	Contact Arrangement			
	31	Voltage	Contact Rating		
TRANSMITTER	32	Transmitter Tag			
	33	Mounting			
	34	Enclosure NEMA Rating			
	35	Power Supply	Voltage		
	36	Output Signal			
	37	Communication Protocol			
CALIBRATION	38	Calibrated Range		2.0-13 pH / -1100-1100 mV	
	39	Vendor Calibration		Field calibrate - Provide calibration certificate	
	40	Accuracy	Repeatability	0.2 Pct of Range	0.1 Pct of Span
OPTIONS	41	Tagging		Affix stainless steel tag with Tag Number	
	42	Sensor Cable		Required	
	43	Flow-through Mount		Required	
	44	Pendelum Adapter			
	45	Air Blast Adapter			
PURCHASE	46	Manufacturer		HACH	
	47	Element Model Number		pH/ORP Combination Sensor	
	48	Transmitter Model Number			
	49	pH Sensor Cable (5 m) Part Number			
	50	Flow-through Mount Part Number		MH373N3NZ	
	51	Pendelum Adapter Part Number			
	52	Air Blast Adapter Part Number			
	53	Purchase Note		3 year warranty	

A07	**Cutter Lateral WTP**
ph/ORP COMBINATION ANALYZER AND TRANSMITTER	**November 9, 2017**
	AE-280-100-02

GENERAL	1	Tag Number	P&ID	AE-280-106-01A	080-I-0002
	2	Loop Title		Flocc/Sed 1 Influent	
	3				
	4	Area Classification		Non-Hazardous	
	5	Line Number	Equipment Number		
	6	Line Size	Line Schedule	N/A	
	7				
PROCESS CONDITIONS	8	Fluid		Raw Water	
	9	Pressure			
	10	Temperature			
	11	Specific Gravity	Viscosity		
	12	Conductivity	Density		
	13	Vapor Pressure	Critical Pressure		
	14				
Element	15	Element Tag		AE-280-106-01A	
	16	Element Type		Convertible	
	17	Element Measurement		pH/ORP Combination	
	18	Range		2.5-12.5 pH / -1000-1000 mV	
	19	Process Connection		0.75 inch NPT	
	20	Body Material		Ryton	
	21	Electrode Material		Glass	
	22	Cable Length		10 feet	
	23	Ambient Temperature Limits			
	24	Process Temperature Limits			
SWITCH	25	Switch Type			
	26	Set Point			
	27	Set Point Direction			
	28	Deadband			
	29	Failure State			
	30	Contact Arrangement			
	31	Voltage	Contact Rating		
TRANSMITTER	32	Transmitter Tag		AIT-280-106-01	
	33	Mounting		Rail	
	34	Enclosure NEMA Rating		NEMA 4X	
	35	Power Supply	Voltage	4-Wire	120 VAC
	36	Output Signal		4-20 mA	
	37	Communication Protocol		HART	
CALIBRATION	38	Calibrated Range		2.0-13 pH / -1100-1100 mV	
	39	Vendor Calibration		Field calibrate - Provide calibration certificate	
	40	Accuracy	Repeatability	0.2 Pct of Range	0.1 Pct of Span
OPTIONS	41	Tagging		Affix stainless steel tag with Tag Number	
	42	Sensor Cable		Required	
	43	Flow-through Mount		Required	
	44	Pendelum Adapter			
	45	Air Blast Adapter			
PURCHASE	46	Manufacturer		HACH	
	47	Element Model Number		pH/ORP Combination Sensor	
	48	Transmitter Model Number			
	49	pH Sensor Cable (5 m) Part Number			
	50	Flow-through Mount Part Number		MH373N3NZ	
	51	Pendelum Adapter Part Number			
	52	Air Blast Adapter Part Number			
	53	Purchase Note		3 year warranty	

A07	**Cutter Lateral WTP**
ph/ORP COMBINATION ANALYZER AND TRANSMITTER	**November 9, 2017**
	AE-280-106-01A

GENERAL	1	Tag Number	P&ID	AE-280-206-01A	080-I-0003
	2	Loop Title		Flocc/Sed 1 Influent	
	3				
	4	Area Classification		Non-Hazardous	
	5	Line Number	Equipment Number		
	6	Line Size	Line Schedule	N/A	
	7				
PROCESS CONDITIONS	8	Fluid		Raw Water	
	9	Pressure			
	10	Temperature			
	11	Specific Gravity	Viscosity		
	12	Conductivity	Density		
	13	Vapor Pressure	Critical Pressure		
	14				
Element	15	Element Tag		AE-280-206-01A	
	16	Element Type		Convertible	
	17	Element Measurement		pH/ORP Combination	
	18	Range		2.5-12.5 pH / -1000-1000 mV	
	19	Process Connection		0.75 inch NPT	
	20	Body Material		Ryton	
	21	Electrode Material		Glass	
	22	Cable Length		10 feet	
	23	Ambient Temperature Limits			
	24	Process Temperature Limits			
SWITCH	25	Switch Type			
	26	Set Point			
	27	Set Point Direction			
	28	Deadband			
	29	Failure State			
	30	Contact Arrangement			
	31	Voltage	Contact Rating		
TRANSMITTER	32	Transmitter Tag		AIT-280-206-01	
	33	Mounting		Rail	
	34	Enclosure NEMA Rating		NEMA 4X	
	35	Power Supply	Voltage	4-Wire	120 VAC
	36	Output Signal		4-20 mA	
	37	Communication Protocol		HART	
CALIBRATION	38	Calibrated Range		2.0-13 pH / -1100-1100 mV	
	39	Vendor Calibration		Field calibrate - Provide calibration certificate	
	40	Accuracy	Repeatability	0.2 Pct of Range	0.1 Pct of Span
OPTIONS	41	Tagging		Affix stainless steel tag with Tag Number	
	42	Sensor Cable		Required	
	43	Flow-through Mount		Required	
	44	Pendelum Adapter			
	45	Air Blast Adapter			
PURCHASE	46	Manufacturer		HACH	
	47	Element Model Number		pH/ORP Combination Sensor	
	48	Transmitter Model Number			
	49	pH Sensor Cable (5 m) Part Number			
	50	Flow-through Mount Part Number		MH373N3NZ	
	51	Pendelum Adapter Part Number			
	52	Air Blast Adapter Part Number			
	53	Purchase Note		3 year warranty	

A07	**Cutter Lateral WTP**
ph/ORP COMBINATION ANALYZER AND TRANSMITTER	**November 9, 2017**
	AE-280-206-01A

GENERAL	1	Tag Number	P&ID	AIT-280-103-01	080-I-0002
	2	Loop Title		Flocc/Sed 1 Influent	
	3				
	4	Area Classification		Non-Hazardous	
	5	Line Number	Equipment Number		
	6	Line Size	Line Schedule	N/A	
	7				
PROCESS CONDITIONS	8	Fluid		Raw Water	
	9	Pressure			
	10	Temperature			
	11	Specific Gravity	Viscosity		
	12	Conductivity	Density		
	13	Vapor Pressure	Critical Pressure		
	14				
Element	15	Element Tag		AE-280-103-01	
	16	Element Type		Convertible	
	17	Element Measurement		pH/ORP Combination	
	18	Range		2.5-12.5 pH / -1000-1000 mV	
	19	Process Connection		1 inch NPT	
	20	Body Material		Ryton	
	21	Electrode Material		Glass	
	22	Cable Length		10 meters	
	23	Ambient Temperature Limits			
	24	Process Temperature Limits			
SWITCH	25	Switch Type			
	26	Set Point			
	27	Set Point Direction			
	28	Deadband			
	29	Failure State			
	30	Contact Arrangement			
	31	Voltage	Contact Rating		
TRANSMITTER	32	Transmitter Tag		AIT-280-106-01	
	33	Mounting			
	34	Enclosure NEMA Rating			
	35	Power Supply	Voltage		
	36	Output Signal			
	37	Communication Protocol			
CALIBRATION	38	Calibrated Range		-2 pH to 14 pH	
	39	Vendor Calibration		Field calibrate - Provide calibration certificate	
	40	Accuracy	Repeatability	0.2 Pct of Range	0.1 Pct of Span
OPTIONS	41	Tagging		Affix stainless steel tag with Tag Number	
	42	Sensor Cable		Required	
	43	Flow-through Mount			
	44	Pendelum Adapter			
	45	Air Blast Adapter			
PURCHASE	46	Manufacturer		HACH	
	47	Element Model Number		pH/ORP Combination Sensor	
	48	Transmitter Model Number		SC200 W/ 1 sensor inputs and 1 output	
	49	pH Sensor Cable (5 m) Part Number			
	50	Flow-through Mount Part Number			
	51	Pendelum Adapter Part Number			
	52	Air Blast Adapter Part Number			
	53	Purchase Note		3 year warranty	

A07	**Cutter Lateral WTP**
ph/ORP COMBINATION ANALYZER AND TRANSMITTER	**November 9, 2017**
	AIT-280-103-01

GENERAL	1	Tag Number	P&ID	AIT-280-203-01	080-I-0003
	2	Loop Title		Flocc/Sed 2 Influent	
	3				
	4	Area Classification		Non-Hazardous	
	5	Line Number	Equipment Number		
	6	Line Size	Line Schedule	N/A	
	7				
PROCESS CONDITIONS	8	Fluid		Raw Water	
	9	Pressure			
	10	Temperature			
	11	Specific Gravity	Viscosity		
	12	Conductivity	Density		
	13	Vapor Pressure	Critical Pressure		
	14				
Element	15	Element Tag		AE-280-203-01	
	16	Element Type		Convertible	
	17	Element Measurement		pH/ORP Combination	
	18	Range		2.5-12.5 pH / -1000-1000 mV	
	19	Process Connection		1 inch NPT	
	20	Body Material		Ryton	
	21	Electrode Material		Glass	
	22	Cable Length		10 meters	
	23	Ambient Temperature Limits			
	24	Process Temperature Limits			
SWITCH	25	Switch Type			
	26	Set Point			
	27	Set Point Direction			
	28	Deadband			
	29	Failure State			
	30	Contact Arrangement			
	31	Voltage	Contact Rating		
TRANSMITTER	32	Transmitter Tag		AIT-280-203-01	
	33	Mounting		Wall	
	34	Enclosure NEMA Rating		NEMA 4X	
	35	Power Supply	Voltage		120v
	36	Output Signal		4-20ma	
	37	Communication Protocol			
CALIBRATION	38	Calibrated Range		-2 pH to 14 pH	
	39	Vendor Calibration		Field calibrate - Provide calibration certificate	
	40	Accuracy	Repeatability	0.2 Pct of Range	0.1 Pct of Span
OPTIONS	41	Tagging		Affix stainless steel tag with Tag Number	
	42	Sensor Cable		Required	
	43	Flow-through Mount			
	44	Pendelum Adapter			
	45	Air Blast Adapter			
PURCHASE	46	Manufacturer		HACH	
	47	Element Model Number		pH/ORP Combination Sensor	
	48	Transmitter Model Number		SC200 W/ 2 sensor inputs and 2 outputs	
	49	pH Sensor Cable (5 m) Part Number			
	50	Flow-through Mount Part Number			
	51	Pendelum Adapter Part Number			
	52	Air Blast Adapter Part Number			
	53	Purchase Note		3 year warranty	

A07	**Cutter Lateral WTP**
	November 9, 2017
ph/ORP COMBINATION ANALYZER AND TRANSMITTER	**AIT-280-203-01**

GENERAL	1	Tag Number	P&ID	AE-300-100-01A	080-I-0004
	2	Loop Title		Filter Influent Ph	
	3				
	4	Area Classification		Non-Hazardous	
	5	Line Number	Equipment Number		
	6	Line Size	Line Schedule	N/A	
	7				
PROCESS CONDITIONS	8	Fluid		Raw Water	
	9	Pressure			
	10	Temperature			
	11	Specific Gravity	Viscosity		
	12	Conductivity	Density		
	13	Vapor Pressure	Critical Pressure		
	14				
Element	15	Element Tag		AE-300-100-01A	
	16	Element Type		Convertible	
	17	Element Measurement		pH/ORP Combination	
	18	Range		2.5-12.5 pH / -1000-1000 mV	
	19	Process Connection		1 inch NPT	
	20	Body Material		Ryton	
	21	Electrode Material		Glass	
	22	Cable Length		10 meters	
	23	Ambient Temperature Limits			
	24	Process Temperature Limits			
SWITCH	25	Switch Type			
	26	Set Point			
	27	Set Point Direction			
	28	Deadband			
	29	Failure State			
	30	Contact Arrangement			
	31	Voltage	Contact Rating		
TRANSMITTER	32	Transmitter Tag		AIT-280-203-01	
	33	Mounting			
	34	Enclosure NEMA Rating			
	35	Power Supply	Voltage		
	36	Output Signal			
	37	Communication Protocol			
CALIBRATION	38	Calibrated Range		-2 pH to 14 pH	
	39	Vendor Calibration		Field calibrate - Provide calibration certificate	
	40	Accuracy	Repeatability	0.2 Pct of Range	0.1 Pct of Span
OPTIONS	41	Tagging		Affix stainless steel tag with Tag Number	
	42	Sensor Cable		Required	
	43	Flow-through Mount			
	44	Pendelum Adapter			
	45	Air Blast Adapter			
PURCHASE	46	Manufacturer		HACH	
	47	Element Model Number		pH/ORP Combination Sensor	
	48	Transmitter Model Number			
	49	pH Sensor Cable (5 m) Part Number			
	50	Flow-through Mount Part Number			
	51	Pendelum Adapter Part Number			
	52	Air Blast Adapter Part Number			
	53	Purchase Note		3 year warranty	

A07	**Cutter Lateral WTP**
ph/ORP COMBINATION ANALYZER AND TRANSMITTER	**November 9, 2017**
	AE-300-100-01A

GENERAL	1	Tag Number	P&ID	AIT-360-101-03	080-I-0013
	2	Loop Title		Finished Water Seal Weir	
	3				
	4	Area Classification		Non-Hazardous	
	5	Line Number	Equipment Number		
	6	Line Size	Line Schedule	N/A	
	7				
PROCESS CONDITIONS	8	Fluid		Finished Water Seal Weir	
	9	Pressure			
	10	Temperature			
	11	Specific Gravity	Viscosity		
	12	Conductivity	Density		
	13	Vapor Pressure	Critical Pressure		
	14				
Element	15	Element Tag		AIT-360-101-03	
	16	Element Type		Convertible	
	17	Element Measurement		pH/ORP Combination	
	18	Range		2.5-12.5 pH / -1000-1000 mV	
	19	Process Connection		0.75 inch NPT	
	20	Body Material		Ryton	
	21	Electrode Material		Glass	
	22	Cable Length		10 feet	
	23	Ambient Temperature Limits			
	24	Process Temperature Limits			
SWITCH	25	Switch Type			
	26	Set Point			
	27	Set Point Direction			
	28	Deadband			
	29	Failure State			
	30	Contact Arrangement			
	31	Voltage	Contact Rating		
TRANSMITTER	32	Transmitter Tag		AIT-360-101-03	
	33	Mounting		Rail	
	34	Enclosure NEMA Rating		NEMA 4X	
	35	Power Supply	Voltage	4-Wire	120 VAC
	36	Output Signal		4-20 mA	
	37	Communication Protocol		HART	
CALIBRATION	38	Calibrated Range		2.0-13 pH / -1100-1100 mV	
	39	Vendor Calibration		Field calibrate - Provide calibration certificate	
	40	Accuracy	Repeatability	0.2 Pct of Range	0.1 Pct of Span
OPTIONS	41	Tagging		Affix stainless steel tag with Tag Number	
	42	Sensor Cable		Required	
	43	Flow-through Mount		Required	
	44	Pendelum Adapter			
	45	Air Blast Adapter			
PURCHASE	46	Manufacturer		HACH	
	47	Element Model Number		pH/ORP Combination Sensor	
	48	Transmitter Model Number		SC200	
	49	pH Sensor Cable (5 m) Part Number			
	50	Flow-through Mount Part Number		MH373N3NZ	
	51	Pendelum Adapter Part Number			
	52	Air Blast Adapter Part Number			
	53	Purchase Note		3 year warranty	

A07	**Cutter Lateral WTP**
ph/ORP COMBINATION ANALYZER AND TRANSMITTER	**November 9, 2017**
	AIT-360-101-03

GENERAL	1	Tag Number	P&ID	FIT-280-101-01	080-I-0001
	2	Loop Title		Rapid Mix Basin 1 Influent Flow	
	3	Area Classification		Non-Hazardous	
	4				
	5	Line Number	Equipment Number		
	6	Line Size	Line Schedule	12 inch	
	7				
PROCESS CONDITIONS	8	Fluid		Plant Influent	
	9				
	10	Min Flow	Max Flow		
	11	Nominal Pressure			
	12	Nominal Temperature			
	13	Specific Gravity	Viscosity	1.0	
	14	Conductivity	Density		
	15	Vapor Pressure	Critical Pressure		
	16				
	17	Vacuum Possibility		No	
	18				
METERING ELEMENT	19	Element Tag		FE-280-101-01	
	20	Element Size		24 inch	
	21	Process Connection		12 inch Class 150 ANSI Flange	
	22	Electrical Connection		0.5 inch NPT	
	23	Tube Material		Stainless Steel	
	24	Liner Material		Polyurethane	
	25	Electrode Type		Bullet Nose	
	26	Electrode Material		316 Stainless Steel	
	27	Range			
	28	Element Cable Length			
	29	Grounding Type	Material	Grounding Ring	
	30	Enclosure NEMA Rating		NEMA 4X	
	31	Minimum Measurable Velocity		0.033 Feet/Sec	
	32				
TRANSMITTER	33	Mounting		Integral	
	34	Enclosure NEMA Rating		NEMA 4X	
	35	Power Supply	Voltage	4 - Wire	120 VAC
	36	Output Signal		4-20 mA	
	37	Communication Protocol		HART	
	38	Calibrated Range			
	39	Low Flow Cutoff			
	40	Ambient Temperature Limits		-5 degF to 140 degF	
	41	Process Temperature Limits		32 degF to 122 degF	
	42				
	43	Accuracy	Repeatability	0.5 Pct of Span	
	44				
OPTIONS	45	Vendor Calibration		Factory calibrate - Provide calibration certificate	
	46	Tagging		Affix stainless steel tag with Tag Number	
	47	Element Mounting Bracket			
	48				
PURCHASE	49	Manufacturer		Endress + Hauser	
	50	Model Number		Promag 400	
	51	Grounding Rings Model Number			
	52	Purchase Note		1 year warranty	
	53				

F04	**Cutter Lateral WTP**
FLOW ELEMENT & TRANSMITTER, ELECTROMAGNETIC	**November 9, 2017**
	FIT-280-101-01

GENERAL	1	Tag Number	P&ID	FIT-280-201-01	080-I-0001
	2	Loop Title		Rapid Mix Basin 2 Influent Flow	
	3	Area Classification		Non-Hazardous	
	4				
	5	Line Number	Equipment Number		
	6	Line Size	Line Schedule	12 inch	
	7				
PROCESS CONDITIONS	8	Fluid		Plant Influent	
	9				
	10	Min Flow	Max Flow		
	11	Nominal Pressure			
	12	Nominal Temperature			
	13	Specific Gravity	Viscosity	1.0	
	14	Conductivity	Density		
	15	Vapor Pressure	Critical Pressure		
	16				
	17	Vacuum Possibility		No	
	18				
METERING ELEMENT	19	Element Tag		FE-280-201-01	
	20	Element Size		24 inch	
	21	Process Connection		12 inch Class 150 ANSI Flange	
	22	Electrical Connection		0.5 inch NPT	
	23	Tube Material		Stainless Steel	
	24	Liner Material		Polyurethane	
	25	Electrode Type		Bullet Nose	
	26	Electrode Material		316 Stainless Steel	
	27	Range			
	28	Element Cable Length			
	29	Grounding Type	Material	Grounding Ring	
	30	Enclosure NEMA Rating		NEMA 4X	
	31	Minimum Measurable Velocity		0.033 Feet/Sec	
	32				
TRANSMITTER	33	Mounting		Integral	
	34	Enclosure NEMA Rating		NEMA 4X	
	35	Power Supply	Voltage	4 - Wire	120 VAC
	36	Output Signal		4-20 mA	
	37	Communication Protocol		HART	
	38	Calibrated Range			
	39	Low Flow Cutoff			
	40	Ambient Temperature Limits		-5 degF to 140 degF	
	41	Process Temperature Limits		32 degF to 122 degF	
	42				
	43	Accuracy	Repeatability	0.5 Pct of Span	
	44				
OPTIONS	45	Vendor Calibration		Factory calibrate - Provide calibration certificate	
	46	Tagging		Affix stainless steel tag with Tag Number	
	47	Element Mounting Bracket			
	48				
PURCHASE	49	Manufacturer		Endress + Hauser	
	50	Model Number		Promag 400	
	51	Grounding Rings Model Number			
	52	Purchase Note		1 year warranty	
	53				

F04	**Cutter Lateral WTP**
FLOW ELEMENT & TRANSMITTER, ELECTROMAGNETIC	**November 9, 2017**
	FIT-280-201-01

GENERAL	1	Tag Number	P&ID	FIT-300-101-01	080-I-0005
	2	Loop Title		Filter 1 Effluent Flow	
	3	Area Classification		Non-Hazardous	
	4				
	5	Line Number	Equipment Number		
	6	Line Size	Line Schedule	8 inch	
	7				
PROCESS CONDITIONS	8	Fluid		Filter Effluent	
	9				
	10	Min Flow	Max Flow		
	11	Nominal Pressure			
	12	Nominal Temperature			
	13	Specific Gravity	Viscosity	1.0	
	14	Conductivity	Density		
	15	Vapor Pressure	Critical Pressure		
	16				
	17	Vacuum Possibility		No	
	18				
METERING ELEMENT	19	Element Tag		FE-300-101-01	
	20	Element Size		8 inch	
	21	Process Connection		8 inch Class 150 ANSI Flange	
	22	Electrical Connection		0.5 inch NPT	
	23	Tube Material		Stainless Steel	
	24	Liner Material		Polyurethane	
	25	Electrode Type		Bullet Nose	
	26	Electrode Material		316 Stainless Steel	
	27	Range			
	28	Element Cable Length			
	29	Grounding Type	Material	Grounding Ring	
	30	Enclosure NEMA Rating		NEMA 4X	
	31	Minimum Measurable Velocity		0.033 Feet/Sec	
	32				
TRANSMITTER	33	Mounting		Integral	
	34	Enclosure NEMA Rating		NEMA 4X	
	35	Power Supply	Voltage	4 - Wire	120 VAC
	36	Output Signal		4-20 mA	
	37	Communication Protocol		HART	
	38	Calibrated Range			
	39	Low Flow Cutoff			
	40	Ambient Temperature Limits		-5 degF to 140 degF	
	41	Process Temperature Limits		32 degF to 122 degF	
	42				
	43	Accuracy	Repeatability	0.5 Pct of Span	
	44				
OPTIONS	45	Vendor Calibration		Factory calibrate - Provide calibration certificate	
	46	Tagging		Affix stainless steel tag with Tag Number	
	47	Element Mounting Bracket			
	48				
PURCHASE	49	Manufacturer		Endress + Hauser	
	50	Model Number		Promag 400	
	51	Grounding Rings Model Number			
	52	Purchase Note		1 year warranty	
	53				

F04	**Cutter Lateral WTP**
FLOW ELEMENT & TRANSMITTER, ELECTROMAGNETIC	**November 9, 2017**
	FIT-300-101-01

GENERAL	1	Tag Number	P&ID	FIT-300-201-01	080-I-0006
	2	Loop Title		Filter 2 Effluent Flow	
	3	Area Classification		Non-Hazardous	
	4				
	5	Line Number	Equipment Number		
	6	Line Size	Line Schedule	8 inch	
	7				
PROCESS CONDITIONS	8	Fluid		Filter Effluent	
	9				
	10	Min Flow	Max Flow		
	11	Nominal Pressure			
	12	Nominal Temperature			
	13	Specific Gravity	Viscosity	1.0	
	14	Conductivity	Density		
	15	Vapor Pressure	Critical Pressure		
	16				
	17	Vacuum Possibility		No	
	18				
METERING ELEMENT	19	Element Tag		FE-300-201-01	
	20	Element Size		8 inch	
	21	Process Connection		8 inch Class 150 ANSI Flange	
	22	Electrical Connection		0.5 inch NPT	
	23	Tube Material		Stainless Steel	
	24	Liner Material		Polyurethane	
	25	Electrode Type		Bullet Nose	
	26	Electrode Material		316 Stainless Steel	
	27	Range			
	28	Element Cable Length			
	29	Grounding Type	Material	Grounding Ring	
	30	Enclosure NEMA Rating		NEMA 4X	
	31	Minimum Measurable Velocity		0.033 Feet/Sec	
	32				
TRANSMITTER	33	Mounting		Integral	
	34	Enclosure NEMA Rating		NEMA 4X	
	35	Power Supply	Voltage	4 - Wire	120 VAC
	36	Output Signal		4-20 mA	
	37	Communication Protocol		HART	
	38	Calibrated Range			
	39	Low Flow Cutoff			
	40	Ambient Temperature Limits		-5 degF to 140 degF	
	41	Process Temperature Limits		32 degF to 122 degF	
	42				
	43	Accuracy	Repeatability	0.5 Pct of Span	
	44				
OPTIONS	45	Vendor Calibration		Factory calibrate - Provide calibration certificate	
	46	Tagging		Affix stainless steel tag with Tag Number	
	47	Element Mounting Bracket			
	48				
PURCHASE	49	Manufacturer		Endress + Hauser	
	50	Model Number		Promag 400	
	51	Grounding Rings Model Number			
	52	Purchase Note		1 year warranty	
	53				

F04	**Cutter Lateral WTP**
FLOW ELEMENT & TRANSMITTER, ELECTROMAGNETIC	**November 9, 2017**
	FIT-300-201-01

GENERAL	1	Tag Number	P&ID	FIT-300-301-01	080-I-0007
	2	Loop Title		Filter 3 Effluent Flow	
	3	Area Classification		Non-Hazardous	
	4				
	5	Line Number	Equipment Number		
	6	Line Size	Line Schedule	8 inch	
	7				
PROCESS CONDITIONS	8	Fluid		Filter Effluent	
	9				
	10	Min Flow	Max Flow		
	11	Nominal Pressure			
	12	Nominal Temperature			
	13	Specific Gravity	Viscosity	1.0	
	14	Conductivity	Density		
	15	Vapor Pressure	Critical Pressure		
	16				
	17	Vacuum Possibility		No	
	18				
METERING ELEMENT	19	Element Tag		FE-300-301-01	
	20	Element Size		8 inch	
	21	Process Connection		8 inch Class 150 ANSI Flange	
	22	Electrical Connection		0.5 inch NPT	
	23	Tube Material		Stainless Steel	
	24	Liner Material		Polyurethane	
	25	Electrode Type		Bullet Nose	
	26	Electrode Material		316 Stainless Steel	
	27	Range			
	28	Element Cable Length			
	29	Grounding Type	Material	Grounding Ring	
	30	Enclosure NEMA Rating		NEMA 4X	
	31	Minimum Measurable Velocity		0.033 Feet/Sec	
	32				
TRANSMITTER	33	Mounting		Integral	
	34	Enclosure NEMA Rating		NEMA 4X	
	35	Power Supply	Voltage	4 - Wire	120 VAC
	36	Output Signal		4-20 mA	
	37	Communication Protocol		HART	
	38	Calibrated Range			
	39	Low Flow Cutoff			
	40	Ambient Temperature Limits		-5 degF to 140 degF	
	41	Process Temperature Limits		32 degF to 122 degF	
	42				
	43	Accuracy	Repeatability	0.5 Pct of Span	
	44				
OPTIONS	45	Vendor Calibration		Factory calibrate - Provide calibration certificate	
	46	Tagging		Affix stainless steel tag with Tag Number	
	47	Element Mounting Bracket			
	48				
PURCHASE	49	Manufacturer		Endress + Hauser	
	50	Model Number		Promag 400	
	51	Grounding Rings Model Number			
	52	Purchase Note		1 year warranty	
	53				

F04	**Cutter Lateral WTP**
FLOW ELEMENT & TRANSMITTER, ELECTROMAGNETIC	**November 9, 2017**
	FIT-300-301-01

GENERAL	1	Tag Number	P&ID	FIT-300-401-01	080-I-0008
	2	Loop Title		Filter 4 Effluent Flow	
	3	Area Classification		Non-Hazardous	
	4				
	5	Line Number	Equipment Number		
	6	Line Size	Line Schedule	8 inch	
	7				
PROCESS CONDITIONS	8	Fluid		Filter Effluent	
	9				
	10	Min Flow	Max Flow		
	11	Nominal Pressure			
	12	Nominal Temperature			
	13	Specific Gravity	Viscosity	1.0	
	14	Conductivity	Density		
	15	Vapor Pressure	Critical Pressure		
	16				
	17	Vacuum Possibility		No	
	18				
METERING ELEMENT	19	Element Tag		FE-300-401-01	
	20	Element Size		8 inch	
	21	Process Connection		8 inch Class 150 ANSI Flange	
	22	Electrical Connection		0.5 inch NPT	
	23	Tube Material		Stainless Steel	
	24	Liner Material		Polyurethane	
	25	Electrode Type		Bullet Nose	
	26	Electrode Material		316 Stainless Steel	
	27	Range			
	28	Element Cable Length			
	29	Grounding Type	Material	Grounding Ring	
	30	Enclosure NEMA Rating		NEMA 4X	
	31	Minimum Measurable Velocity		0.033 Feet/Sec	
	32				
TRANSMITTER	33	Mounting		Integral	
	34	Enclosure NEMA Rating		NEMA 4X	
	35	Power Supply	Voltage	4 - Wire	120 VAC
	36	Output Signal		4-20 mA	
	37	Communication Protocol		HART	
	38	Calibrated Range			
	39	Low Flow Cutoff			
	40	Ambient Temperature Limits		-5 degF to 140 degF	
	41	Process Temperature Limits		32 degF to 122 degF	
	42				
	43	Accuracy	Repeatability	0.5 Pct of Span	
	44				
OPTIONS	45	Vendor Calibration		Factory calibrate - Provide calibration certificate	
	46	Tagging		Affix stainless steel tag with Tag Number	
	47	Element Mounting Bracket			
	48				
PURCHASE	49	Manufacturer		Endress + Hauser	
	50	Model Number		Promag 400	
	51	Grounding Rings Model Number			
	52	Purchase Note		1 year warranty	
	53				

F04	**Cutter Lateral WTP**
FLOW ELEMENT & TRANSMITTER, ELECTROMAGNETIC	**November 9, 2017**
	FIT-300-401-01

GENERAL	1	Tag Number	P&ID	FIT-300-105-05	080-I-0011
	2	Loop Title		GAC Supply Pump Combined Discharge	
	3	Area Classification		Non-Hazardous	
	4				
	5	Line Number	Equipment Number		
	6	Line Size	Line Schedule	8 inch	
	7				
PROCESS CONDITIONS	8	Fluid		Filter Effluent	
	9				
	10	Min Flow	Max Flow		
	11	Nominal Pressure			
	12	Nominal Temperature			
	13	Specific Gravity	Viscosity	1.0	
	14	Conductivity	Density		
	15	Vapor Pressure	Critical Pressure		
	16				
	17	Vacuum Possibility		No	
	18				
METERING ELEMENT	19	Element Tag		FE-300-105-05	
	20	Element Size		8 inch	
	21	Process Connection		8 inch Class 150 ANSI Flange	
	22	Electrical Connection		0.5 inch NPT	
	23	Tube Material		Stainless Steel	
	24	Liner Material		Polyurethane	
	25	Electrode Type		Bullet Nose	
	26	Electrode Material		316 Stainless Steel	
	27	Range			
	28	Element Cable Length			
	29	Grounding Type	Material	Grounding Ring	
	30	Enclosure NEMA Rating		NEMA 4X	
	31	Minimum Measurable Velocity		0.033 Feet/Sec	
	32				
TRANSMITTER	33	Mounting		Integral	
	34	Enclosure NEMA Rating		NEMA 4X	
	35	Power Supply	Voltage	4 - Wire	120 VAC
	36	Output Signal		4-20 mA	
	37	Communication Protocol		HART	
	38	Calibrated Range			
	39	Low Flow Cutoff			
	40	Ambient Temperature Limits		-5 degF to 140 degF	
	41	Process Temperature Limits		32 degF to 122 degF	
	42				
	43	Accuracy	Repeatability	0.5 Pct of Span	
	44				
OPTIONS	45	Vendor Calibration		Factory calibrate - Provide calibration certificate	
	46	Tagging		Affix stainless steel tag with Tag Number	
	47	Element Mounting Bracket			
	48				
PURCHASE	49	Manufacturer		Endress + Hauser	
	50	Model Number		Promag 400	
	51	Grounding Rings Model Number			
	52	Purchase Note		1 year warranty	
	53				

F04	**Cutter Lateral WTP**
FLOW ELEMENT & TRANSMITTER, ELECTROMAGNETIC	**November 9, 2017**
	FIT-300-105-05

GENERAL	1	Tag Number	P&ID	FIT-360-304-01	080-I-0014
	2	Loop Title		FW Flow to Tank T3	
	3	Area Classification		Non-Hazardous	
	4				
	5	Line Number	Equipment Number		
	6	Line Size	Line Schedule	12 inch	
	7				
PROCESS CONDITIONS	8	Fluid		Filter Effluent	
	9				
	10	Min Flow	Max Flow		
	11	Nominal Pressure			
	12	Nominal Temperature			
	13	Specific Gravity	Viscosity	1.0	
	14	Conductivity	Density		
	15	Vapor Pressure	Critical Pressure		
	16				
	17	Vacuum Possibility		No	
	18				
METERING ELEMENT	19	Element Tag		FE-360-304-01	
	20	Element Size		12 inch	
	21	Process Connection		12 inch Class 150 ANSI Flange	
	22	Electrical Connection		0.5 inch NPT	
	23	Tube Material		Stainless Steel	
	24	Liner Material		Polyurethane	
	25	Electrode Type		Bullet Nose	
	26	Electrode Material		316 Stainless Steel	
	27	Range			
	28	Element Cable Length			
	29	Grounding Type	Material	Grounding Ring	
	30	Enclosure NEMA Rating		NEMA 4X	
	31	Minimum Measurable Velocity		0.033 Feet/Sec	
	32				
TRANSMITTER	33	Mounting		Integral	
	34	Enclosure NEMA Rating		NEMA 4X	
	35	Power Supply	Voltage	4 - Wire	120 VAC
	36	Output Signal		4-20 mA	
	37	Communication Protocol		HART	
	38	Calibrated Range			
	39	Low Flow Cutoff			
	40	Ambient Temperature Limits		-5 degF to 140 degF	
	41	Process Temperature Limits		32 degF to 122 degF	
	42				
	43	Accuracy	Repeatability	0.5 Pct of Span	
	44				
OPTIONS	45	Vendor Calibration		Factory calibrate - Provide calibration certificate	
	46	Tagging		Affix stainless steel tag with Tag Number	
	47	Element Mounting Bracket			
	48				
PURCHASE	49	Manufacturer		Endress + Hauser	
	50	Model Number		Promag 400	
	51	Grounding Rings Model Number			
	52	Purchase Note		1 year warranty	
	53				

F04	**Cutter Lateral WTP**
FLOW ELEMENT & TRANSMITTER, ELECTROMAGNETIC	**November 9, 2017**
	FIT-360-304-01

GENERAL	1	Tag Number	P&ID	FIT-360-305-01	080-I-0014
	2	Loop Title		FW Flow to Filters and BW	
	3	Area Classification		Non-Hazardous	
	4				
	5	Line Number	Equipment Number		
	6	Line Size	Line Schedule	14 inch	
	7				
PROCESS CONDITIONS	8	Fluid		Filter Effluent	
	9				
	10	Min Flow	Max Flow		
	11	Nominal Pressure			
	12	Nominal Temperature			
	13	Specific Gravity	Viscosity	1.0	
	14	Conductivity	Density		
	15	Vapor Pressure	Critical Pressure		
	16				
	17	Vacuum Possibility		No	
	18				
METERING ELEMENT	19	Element Tag		FE-360-305-01	
	20	Element Size		14 inch	
	21	Process Connection		14 inch Class 150 ANSI Flange	
	22	Electrical Connection		0.5 inch NPT	
	23	Tube Material		Stainless Steel	
	24	Liner Material		Polyurethane	
	25	Electrode Type		Bullet Nose	
	26	Electrode Material		316 Stainless Steel	
	27	Range			
	28	Element Cable Length			
	29	Grounding Type	Material	Grounding Ring	
	30	Enclosure NEMA Rating		NEMA 4X	
	31	Minimum Measurable Velocity		0.033 Feet/Sec	
	32				
TRANSMITTER	33	Mounting		Integral	
	34	Enclosure NEMA Rating		NEMA 4X	
	35	Power Supply	Voltage	4 - Wire	120 VAC
	36	Output Signal		4-20 mA	
	37	Communication Protocol		HART	
	38	Calibrated Range			
	39	Low Flow Cutoff			
	40	Ambient Temperature Limits		-5 degF to 140 degF	
	41	Process Temperature Limits		32 degF to 122 degF	
	42				
	43	Accuracy	Repeatability	0.5 Pct of Span	
	44				
OPTIONS	45	Vendor Calibration		Factory calibrate - Provide calibration certificate	
	46	Tagging		Affix stainless steel tag with Tag Number	
	47	Element Mounting Bracket			
	48				
PURCHASE	49	Manufacturer		Endress + Hauser	
	50	Model Number		Promag 400	
	51	Grounding Rings Model Number			
	52	Purchase Note		1 year warranty	
	53				

F04	**Cutter Lateral WTP**
FLOW ELEMENT & TRANSMITTER, ELECTROMAGNETIC	**November 9, 2017**
	FIT-360-305-01

GENERAL	1	Tag Number	P&ID	FIT-420-100-03	080-I-0016
	2	Loop Title		Sludge Flow to Drying Ponds	
	3	Area Classification		Non-Hazardous	
	4				
	5	Line Number	Equipment Number		
	6	Line Size	Line Schedule	4 inch	
	7				
PROCESS CONDITIONS	8	Fluid		Sludge Flow to Drying Ponds	
	9				
	10	Min Flow	Max Flow		
	11	Nominal Pressure			
	12	Nominal Temperature			
	13	Specific Gravity	Viscosity	1.0	
	14	Conductivity	Density		
	15	Vapor Pressure	Critical Pressure		
	16				
	17	Vacuum Possibility		No	
	18				
METERING ELEMENT	19	Element Tag		FE-420-100-03	
	20	Element Size		4 inch	
	21	Process Connection		4 inch Class 150 ANSI Flange	
	22	Electrical Connection		0.5 inch NPT	
	23	Tube Material		Stainless Steel	
	24	Liner Material		Polyurethane	
	25	Electrode Type		Bullet Nose	
	26	Electrode Material		316 Stainless Steel	
	27	Range			
	28	Element Cable Length			
	29	Grounding Type	Material	Grounding Ring	
	30	Enclosure NEMA Rating		NEMA 4X	
	31	Minimum Measurable Velocity		0.033 Feet/Sec	
	32				
TRANSMITTER	33	Mounting		Integral	
	34	Enclosure NEMA Rating		NEMA 4X	
	35	Power Supply	Voltage	4 - Wire	120 VAC
	36	Output Signal		4-20 mA	
	37	Communication Protocol		HART	
	38	Calibrated Range			
	39	Low Flow Cutoff			
	40	Ambient Temperature Limits		-5 degF to 140 degF	
	41	Process Temperature Limits		32 degF to 122 degF	
	42				
	43	Accuracy	Repeatability	0.5 Pct of Span	
	44				
OPTIONS	45	Vendor Calibration		Factory calibrate - Provide calibration certificate	
	46	Tagging		Affix stainless steel tag with Tag Number	
	47	Element Mounting Bracket			
	48				
PURCHASE	49	Manufacturer		Endress + Hauser	
	50	Model Number		Promag 400	
	51	Grounding Rings Model Number			
	52	Purchase Note		1 year warranty	
	53				

F04	**Cutter Lateral WTP**
FLOW ELEMENT & TRANSMITTER, ELECTROMAGNETIC	**November 9, 2017**
	FIT-420-100-03

GENERAL	1	Tag Number	P&ID	FIT-460-100-04	080-I-0017
	2	Loop Title		Recycle/EVD Flow	
	3	Area Classification		Non-Hazardous	
	4				
	5	Line Number	Equipment Number		
	6	Line Size	Line Schedule	6 inch	
	7				
PROCESS CONDITIONS	8	Fluid		Recycle/EVD Flow	
	9				
	10	Min Flow	Max Flow		
	11	Nominal Pressure			
	12	Nominal Temperature			
	13	Specific Gravity	Viscosity	1.0	
	14	Conductivity	Density		
	15	Vapor Pressure	Critical Pressure		
	16				
	17	Vacuum Possibility		No	
	18				
METERING ELEMENT	19	Element Tag		FE-460-100-04	
	20	Element Size		6 inch	
	21	Process Connection		6 inch Class 150 ANSI Flange	
	22	Electrical Connection		0.5 inch NPT	
	23	Tube Material		Stainless Steel	
	24	Liner Material		Polyurethane	
	25	Electrode Type		Bullet Nose	
	26	Electrode Material		316 Stainless Steel	
	27	Range			
	28	Element Cable Length			
	29	Grounding Type	Material	Grounding Ring	
	30	Enclosure NEMA Rating		NEMA 4X	
	31	Minimum Measurable Velocity		0.033 Feet/Sec	
	32				
TRANSMITTER	33	Mounting		Integral	
	34	Enclosure NEMA Rating		NEMA 4X	
	35	Power Supply	Voltage	4 - Wire	120 VAC
	36	Output Signal		4-20 mA	
	37	Communication Protocol		HART	
	38	Calibrated Range			
	39	Low Flow Cutoff			
	40	Ambient Temperature Limits		-5 degF to 140 degF	
	41	Process Temperature Limits		32 degF to 122 degF	
	42				
	43	Accuracy	Repeatability	0.5 Pct of Span	
	44				
OPTIONS	45	Vendor Calibration		Factory calibrate - Provide calibration certificate	
	46	Tagging		Affix stainless steel tag with Tag Number	
	47	Element Mounting Bracket			
	48				
PURCHASE	49	Manufacturer		Endress + Hauser	
	50	Model Number		Promag 400	
	51	Grounding Rings Model Number			
	52	Purchase Note		1 year warranty	
	53				

F04	**Cutter Lateral WTP**
FLOW ELEMENT & TRANSMITTER, ELECTROMAGNETIC	**November 9, 2017**
	FIT-460-100-04

GENERAL	1	Tag Number	P&ID	LIT-380-100-02	080-I-0019
	2	Loop Title		Sulfuric Acid Storage Tank	
	3	Area Classification		Non-Hazardous	
	4				
	5				
	6				
PROCESS CONDITIONS	7	Fluid		Sulfuric Acid (SO4)	
	8	Pressure		0-10 ft	
	9	Temperature		70 degF	
	10	Specific Gravity		1.83	
	11				
	12				
	13				
ELEMENT	14	Element Type		Metal Process Isolating Diaphragm, Flanged	
	15	Element Material		316L SS	
	16	Overpressure Body Rating		600 PSI	
	17	Instrument Body Material		316L SS	
	18	Wetted Materials		Alloy C276 (Hastalloy C)	
	19	Process Connection		2" ANSI, 150 lb, 316L	
	20	Measurable Limits			
	21	Ambient Temperature Limits		-4 degF to 158 degF	
	22	Process Temperature Limits		14 degF to 185 degF	
	23	Tag Number		LE-380-100-02	
	24				
	25				
	26				
	27				
	28				
	29				
	30				
	31				
	32				
	33				
TRANSMITTER	34				
	35	Enclosure NEMA Rating		NEMA 4X	
	36	Power Supply	Voltage	2-Wire	24 VDC
	37	Output Signal		4-20 mA	
	38	Communication Protocol		HART	
	39	Range		0 - 40 feet	
	40	Cable		Shielded, 2-wire, twisted pair	
CALIBRATION	41	Calibrated Range		0 - 16 feet	
	42	Vendor Calibration		Factory calibrate - Provide calibration certificate	
	43	Zero Elevation			
	44	Zero Reference			
	45	Accuracy		0.2 Pct of Span	
	46				
OPTIONS	47	Multi-Valve Manifold			
	48	Tagging		Affix stainless steel tag with Tag Number	
	49	Mounting Bracket			
PURCHASE	50	Manufacturer		Endress + Hauser	
	51	Model Number		FMD77	
	52				
	53				

L10	**Cutter Lateral WTP**
LEVEL TRANSMITTER - PRESSURE	**November 9, 2017**
	LIT-380-100-02

GENERAL	1	Tag Number	P&ID	LIT-380-200-02	080-I-0020
	2	Loop Title		Ferric Chloride Storage Tank	
	3	Area Classification		Non-Hazardous	
	4				
	5				
	6				
PROCESS CONDITIONS	7	Fluid		Ferric Chloride (FeCl)	
	8	Pressure		0-14 ft	
	9	Temperature		70 degF	
	10	Specific Gravity		1.43	
	11				
	12				
	13				
ELEMENT	14	Element Type		Metal Process Isolating Diaphragm, Flanged	
	15	Element Material		316L SS	
	16	Overpressure Body Rating		600 PSI	
	17	Instrument Body Material		316L SS	
	18	Wetted Materials		Alloy C276 (Hastalloy C)	
	19	Process Connection		2" ANSI, 150 lb, 316L	
	20	Measurable Limits			
	21	Ambient Temperature Limits		-4 degF to 158 degF	
	22	Process Temperature Limits		14 degF to 185 degF	
	23	Tag Number		LE-380-200-02	
	24				
	25				
	26				
	27				
	28				
	29				
	30				
	31				
	32				
	33				
TRANSMITTER	34				
	35	Enclosure NEMA Rating		NEMA 4X	
	36	Power Supply	Voltage	2-Wire	24 VDC
	37	Output Signal		4-20 mA	
	38	Communication Protocol		HART	
	39	Range		0 - 40 feet	
	40	Cable		Shielded, 2-wire, twisted pair	
CALIBRATION	41	Calibrated Range		0 - 16 feet	
	42	Vendor Calibration		Factory calibrate - Provide calibration certificate	
	43	Zero Elevation			
	44	Zero Reference			
	45	Accuracy		0.2 Pct of Span	
	46				
OPTIONS	47	Multi-Valve Manifold			
	48	Tagging		Affix stainless steel tag with Tag Number	
	49	Mounting Bracket			
PURCHASE	50	Manufacturer		Endress + Hauser	
	51	Model Number		FMD77	
	52				
	53				

L10	**Cutter Lateral WTP**
LEVEL TRANSMITTER - PRESSURE	**November 9, 2017**
	LIT-380-200-02

GENERAL	1	Tag Number	P&ID	LIT-380-300-02	080-I-0021
	2	Loop Title		Sodium HypoChlorite Storage Tank	
	3	Area Classification		Non-Hazardous	
	4				
	5				
	6				
PROCESS CONDITIONS	7	Fluid		Sodium HypoChlorite	
	8	Pressure		0-14 ft	
	9	Temperature		70 degF	
	10	Specific Gravity		1.21	
	11				
	12				
	13				
ELEMENT	14	Element Type		Metal Process Isolating Diaphragm, Flanged	
	15	Element Material		316L SS	
	16	Overpressure Body Rating		600 PSI	
	17	Instrument Body Material		316L SS	
	18	Wetted Materials		Alloy C276 (Hastalloy C)	
	19	Process Connection		2" ANSI, 150 lb, 316L	
	20	Measurable Limits			
	21	Ambient Temperature Limits		-4 degF to 158 degF	
	22	Process Temperature Limits		14 degF to 185 degF	
	23	Tag Number		LE-380-300-02	
	24				
	25				
	26				
	27				
	28				
	29				
	30				
	31				
	32				
	33				
TRANSMITTER	34				
	35	Enclosure NEMA Rating		NEMA 4X	
	36	Power Supply	Voltage	2-Wire	24 VDC
	37	Output Signal		4-20 mA	
	38	Communication Protocol		HART	
	39	Range		0 - 40 feet	
	40	Cable		Shielded, 2-wire, twisted pair	
CALIBRATION	41	Calibrated Range		0 - 16 feet	
	42	Vendor Calibration		Factory calibrate - Provide calibration certificate	
	43	Zero Elevation			
	44	Zero Reference			
	45	Accuracy		0.2 Pct of Span	
	46				
OPTIONS	47	Multi-Valve Manifold			
	48	Tagging		Affix stainless steel tag with Tag Number	
	49	Mounting Bracket			
PURCHASE	50	Manufacturer		Endress + Hauser	
	51	Model Number		FMD77	
	52				
	53				

L10	**Cutter Lateral WTP**
LEVEL TRANSMITTER - PRESSURE	**November 9, 2017**
	LIT-380-300-02

GENERAL	1	Tag Number	P&ID	LIT-380-400-02	080-I-0022
	2	Loop Title		Sodium Hydroxide Storage Tank	
	3	Area Classification		Non-Hazardous	
	4				
	5				
	6				
PROCESS CONDITIONS	7	Fluid		Sodium Hydroxide (NaOH)	
	8	Pressure		0-13 ft	
	9	Temperature		70 degF	
	10	Specific Gravity		1.54	
	11				
	12				
	13				
ELEMENT	14	Element Type		Metal Process Isolating Diaphragm, Flanged	
	15	Element Material		316L SS	
	16	Overpressure Body Rating		600 PSI	
	17	Instrument Body Material		316L SS	
	18	Wetted Materials		Alloy C276 (Hastalloy C)	
	19	Process Connection		2" ANSI, 150 lb, 316L	
	20	Measurable Limits			
	21	Ambient Temperature Limits		-4 degF to 158 degF	
	22	Process Temperature Limits		14 degF to 185 degF	
	23	Tag Number		LE-380-400-02	
	24				
	25				
	26				
	27				
	28				
	29				
	30				
	31				
	32				
	33				
TRANSMITTER	34				
	35	Enclosure NEMA Rating		NEMA 4X	
	36	Power Supply	Voltage	2-Wire	24 VDC
	37	Output Signal		4-20 mA	
	38	Communication Protocol		HART	
	39	Range		0 - 40 feet	
	40	Cable		Shielded, 2-wire, twisted pair	
CALIBRATION	41	Calibrated Range		0 - 16 feet	
	42	Vendor Calibration		Factory calibrate - Provide calibration certificate	
	43	Zero Elevation			
	44	Zero Reference			
	45	Accuracy		0.2 Pct of Span	
	46				
OPTIONS	47	Multi-Valve Manifold			
	48	Tagging		Affix stainless steel tag with Tag Number	
	49	Mounting Bracket			
PURCHASE	50	Manufacturer		Endress + Hauser	
	51	Model Number		FMD77	
	52				
	53				

L10	**Cutter Lateral WTP**
LEVEL TRANSMITTER - PRESSURE	**November 9, 2017**
	LIT-380-400-02

GENERAL	1	Tag Number	P&ID	LIT-900-100-01	080-I-0030
	2	Loop Title		Tank T3 Level	
	3	Area Classification		Non-Hazardous	
	4				
	5				
	6				
PROCESS CONDITIONS	7	Fluid		Finished water	
	8	Pressure		0-45 ft	
	9	Temperature		70 degF	
	10	Specific Gravity		1.54	
	11				
	12				
	13				
ELEMENT	14	Element Type		Metal Process Isolating Diaphragm, Flanged	
	15	Element Material		316L SS	
	16	Overpressure Body Rating		600 PSI	
	17	Instrument Body Material		316L SS	
	18	Wetted Materials		Alloy C276 (Hastalloy C)	
	19	Process Connection		2" ANSI, 150 lb, 316L	
	20	Measurable Limits			
	21	Ambient Temperature Limits		-4 degF to 158 degF	
	22	Process Temperature Limits		14 degF to 185 degF	
	23	Tag Number		LE-900-100-01	
	24				
	25				
	26				
	27				
	28				
	29				
	30				
	31				
	32				
	33				
TRANSMITTER	34				
	35	Enclosure NEMA Rating		NEMA 4X	
	36	Power Supply	Voltage	2-Wire	24 VDC
	37	Output Signal		4-20 mA	
	38	Communication Protocol		HART	
	39	Range		0 - 40 feet	
	40	Cable		Shielded, 2-wire, twisted pair	
CALIBRATION	41	Calibrated Range		0 - 16 feet	
	42	Vendor Calibration		Factory calibrate - Provide calibration certificate	
	43	Zero Elevation			
	44	Zero Reference			
	45	Accuracy		0.2 Pct of Span	
	46				
OPTIONS	47	Multi-Valve Manifold			
	48	Tagging		Affix stainless steel tag with Tag Number	
	49	Mounting Bracket			
PURCHASE	50	Manufacturer		Endress + Hauser	
	51	Model Number		FMD77	
	52				
	53				

L10	**Cutter Lateral WTP**
LEVEL TRANSMITTER - PRESSURE	**November 9, 2017**
	LIT-900-100-01

GENERAL	1	Tag Number	P&ID	PI-360-102-01	080-I-0013
	2	Loop Title		Domestic Water Pump #1	
	3				
	4	Area Classification		Non-Hazardous	
	5	Line Size			
	6				
	7				
PROCESS CONDITIONS	8	Fluid		Potable Water	
	9	Min Pressure	Max Pressure	0 psi	100 psi
	10	Temperature		Ambient	
	11	Specific Gravity		1.0	
	12				
	13				
	14				
INDICATOR	15	Type		Bourdon Tube	
	16	Range		0-160 psi	
	17	Dial Size		4.5 inches	
	18	Dial Color		White	
	19	Process Connection		0.5 inch NPT	
	20	Mounting		Lower Stem	
	21	Movement Dampening		Glycerine	
	22	Case Material		Phenolic	
	23	Window Material		Acrylic	
	24				
	25	Blowout Protection		Case Back	
	26	Tube Materials		Stainless Steel	
	27	Socket Material		Stainless Steel	
	28				
DIAPHRAGM SEAL - ANNULAR SEAL	29	Type			
	30	Process Connection			
	31	Body Material			
	32	Diaphragm / Sleeve Material			
	33				
	34	Capillary Material			
	35	Capillary Length			
	36	Fill Fluid			
	37	Flushing Connection			
	38				
	39	Manufacturer			
	40	Model Number			
CALIBRATION	41				
	42	Vendor Calibration		Factory calibrate - Provide calibration certificate	
	43				
	44	Accuracy		0.5 Pct of Range	
	45				
OPTIONS	46	Tagging		Affix stainless steel tag with Tag Number	
	47				
	48				
PURCHASE	49	Manufacturer		Ashcroft	
	50	Model Number		1259	
	51				
	52				
	53				

P04	**Cutter Lateral WTP**
PRESSURE GAUGE	**November 9, 2017**
	PI-360-102-01

GENERAL	1	Tag Number	P&ID	PI-360-102-02	080-I-0013
	2	Loop Title		Domestic Water Pump #2	
	3				
	4	Area Classification		Non-Hazardous	
	5	Line Size			
	6				
	7				
PROCESS CONDITIONS	8	Fluid		Potable Water	
	9	Min Pressure	Max Pressure	0 psi	100 psi
	10	Temperature		Ambient	
	11	Specific Gravity		1.0	
	12				
	13				
	14				
INDICATOR	15	Type		Bourdon Tube	
	16	Range		0-160 psi	
	17	Dial Size		4.5 inches	
	18	Dial Color		White	
	19	Process Connection		0.5 inch NPT	
	20	Mounting		Lower Stem	
	21	Movement Dampening		Glycerine	
	22	Case Material		Phenolic	
	23	Window Material		Acrylic	
	24				
	25	Blowout Protection		Case Back	
	26	Tube Materials		Stainless Steel	
	27	Socket Material		Stainless Steel	
	28				
DIAPHRAGM SEAL - ANNULAR SEAL	29	Type			
	30	Process Connection			
	31	Body Material			
	32	Diaphragm / Sleeve Material			
	33				
	34	Capillary Material			
	35	Capillary Length			
	36	Fill Fluid			
	37	Flushing Connection			
	38				
	39	Manufacturer			
	40	Model Number			
CALIBRATION	41				
	42	Vendor Calibration		Factory calibrate - Provide calibration certificate	
	43				
	44	Accuracy		0.5 Pct of Range	
	45				
OPTIONS	46	Tagging		Affix stainless steel tag with Tag Number	
	47				
	48				
PURCHASE	49	Manufacturer		Ashcroft	
	50	Model Number		1259	
	51				
	52				
	53				

P04	**Cutter Lateral WTP**
PRESSURE GAUGE	**November 9, 2017**
	PI-360-102-02

GENERAL	1	Tag Number	P&ID	PI-500-102-01	080-I-0013
	2	Loop Title		Fire Pump Discharge	
	3				
	4	Area Classification		Non-Hazardous	
	5	Line Size			
	6				
	7				
PROCESS CONDITIONS	8	Fluid		Finished Water	
	9	Min Pressure	Max Pressure	0 psi	100 psi
	10	Temperature		Ambient	
	11	Specific Gravity		1.0	
	12				
	13				
	14				
INDICATOR	15	Type		Bourdon Tube	
	16	Range		0-160 psi	
	17	Dial Size		4.5 inches	
	18	Dial Color		White	
	19	Process Connection		0.5 inch NPT	
	20	Mounting		Lower Stem	
	21	Movement Dampening		Glycerine	
	22	Case Material		Phenolic	
	23	Window Material		Acrylic	
	24				
	25	Blowout Protection		Case Back	
	26	Tube Materials		Stainless Steel	
	27	Socket Material		Stainless Steel	
	28				
DIAPHRAGM SEAL - ANNULAR SEAL	29	Type			
	30	Process Connection			
	31	Body Material			
	32	Diaphragm / Sleeve Material			
	33				
	34	Capillary Material			
	35	Capillary Length			
	36	Fill Fluid			
	37	Flushing Connection			
	38				
	39	Manufacturer			
	40	Model Number			
CALIBRATION	41				
	42	Vendor Calibration		Factory calibrate - Provide calibration certificate	
	43				
	44	Accuracy		0.5 Pct of Range	
	45				
OPTIONS	46	Tagging		Affix stainless steel tag with Tag Number	
	47				
	48				
PURCHASE	49	Manufacturer		Ashcroft	
	50	Model Number		1259	
	51				
	52				
	53				

P04	**Cutter Lateral WTP**
PRESSURE GAUGE	**November 9, 2017**
	PI-500-102-01

GENERAL	1	Tag Number	P&ID	PI-360-104-01	080-I-0014
	2	Loop Title		Finished Water Pump #1	
	3				
	4	Area Classification		Non-Hazardous	
	5	Line Size			
	6				
	7				
PROCESS CONDITIONS	8	Fluid		Potable Water	
	9	Min Pressure	Max Pressure	0 psi	200 psi
	10	Temperature		Ambient	
	11	Specific Gravity		1.0	
	12				
	13				
	14				
INDICATOR	15	Type		Bourdon Tube	
	16	Range		0-200 psi	
	17	Dial Size		4.5 inches	
	18	Dial Color		White	
	19	Process Connection		0.5 inch NPT	
	20	Mounting		Lower Stem	
	21	Movement Dampening		Glycerine	
	22	Case Material		Phenolic	
	23	Window Material		Acrylic	
	24				
	25	Blowout Protection		Case Back	
	26	Tube Materials		Stainless Steel	
	27	Socket Material		Stainless Steel	
	28				
DIAPHRAGM SEAL - ANNULAR SEAL	29	Type			
	30	Process Connection			
	31	Body Material			
	32	Diaphragm / Sleeve Material			
	33				
	34	Capillary Material			
	35	Capillary Length			
	36	Fill Fluid			
	37	Flushing Connection			
	38				
	39	Manufacturer			
	40	Model Number			
CALIBRATION	41				
	42	Vendor Calibration		Factory calibrate - Provide calibration certificate	
	43				
	44	Accuracy		0.5 Pct of Range	
	45				
OPTIONS	46	Tagging		Affix stainless steel tag with Tag Number	
	47				
	48				
PURCHASE	49	Manufacturer		Ashcroft	
	50	Model Number		1259	
	51				
	52				
	53				

P04	**Cutter Lateral WTP**
PRESSURE GAUGE	**November 9, 2017**
	PI-360-104-01

GENERAL	1	Tag Number	P&ID	PI-360-104-02	080-I-0014
	2	Loop Title		Finished Water Pump #2	
	3				
	4	Area Classification		Non-Hazardous	
	5	Line Size			
	6				
	7				
PROCESS CONDITIONS	8	Fluid		Potable Water	
	9	Min Pressure	Max Pressure	0 psi	200 psi
	10	Temperature		Ambient	
	11	Specific Gravity		1.0	
	12				
	13				
	14				
INDICATOR	15	Type		Bourdon Tube	
	16	Range		0-200 psi	
	17	Dial Size		4.5 inches	
	18	Dial Color		White	
	19	Process Connection		0.5 inch NPT	
	20	Mounting		Lower Stem	
	21	Movement Dampening		Glycerine	
	22	Case Material		Phenolic	
	23	Window Material		Acrylic	
	24				
	25	Blowout Protection		Case Back	
	26	Tube Materials		Stainless Steel	
	27	Socket Material		Stainless Steel	
	28				
DIAPHRAGM SEAL - ANNULAR SEAL	29	Type			
	30	Process Connection			
	31	Body Material			
	32	Diaphragm / Sleeve Material			
	33				
	34	Capillary Material			
	35	Capillary Length			
	36	Fill Fluid			
	37	Flushing Connection			
	38				
	39	Manufacturer			
	40	Model Number			
CALIBRATION	41				
	42	Vendor Calibration		Factory calibrate - Provide calibration certificate	
	43				
	44	Accuracy		0.5 Pct of Range	
	45				
OPTIONS	46	Tagging		Affix stainless steel tag with Tag Number	
	47				
	48				
PURCHASE	49	Manufacturer		Ashcroft	
	50	Model Number		1259	
	51				
	52				
	53				

P04	**Cutter Lateral WTP**
PRESSURE GAUGE	**November 9, 2017**
	PI-360-104-02

GENERAL	1	Tag Number	P&ID	PI-360-104-03	080-I-0014
	2	Loop Title		Finished Water Pump #3	
	3				
	4	Area Classification		Non-Hazardous	
	5	Line Size			
	6				
	7				
PROCESS CONDITIONS	8	Fluid		Potable Water	
	9	Min Pressure	Max Pressure	0 psi	200 psi
	10	Temperature		Ambient	
	11	Specific Gravity		1.0	
	12				
	13				
	14				
INDICATOR	15	Type		Bourdon Tube	
	16	Range		0-200 psi	
	17	Dial Size		4.5 inches	
	18	Dial Color		White	
	19	Process Connection		0.5 inch NPT	
	20	Mounting		Lower Stem	
	21	Movement Dampening		Glycerine	
	22	Case Material		Phenolic	
	23	Window Material		Acrylic	
	24				
	25	Blowout Protection		Case Back	
	26	Tube Materials		Stainless Steel	
	27	Socket Material		Stainless Steel	
	28				
DIAPHRAGM SEAL - ANNULAR SEAL	29	Type			
	30	Process Connection			
	31	Body Material			
	32	Diaphragm / Sleeve Material			
	33				
	34	Capillary Material			
	35	Capillary Length			
	36	Fill Fluid			
	37	Flushing Connection			
	38				
	39	Manufacturer			
	40	Model Number			
CALIBRATION	41				
	42	Vendor Calibration		Factory calibrate - Provide calibration certificate	
	43				
	44	Accuracy		0.5 Pct of Range	
	45				
OPTIONS	46	Tagging		Affix stainless steel tag with Tag Number	
	47				
	48				
PURCHASE	49	Manufacturer		Ashcroft	
	50	Model Number		1259	
	51				
	52				
	53				

P04	**Cutter Lateral WTP**
PRESSURE GAUGE	**November 9, 2017**
	PI-360-104-03

GENERAL	1	Tag Number	P&ID	PI-360-104-04	080-I-0014
	2	Loop Title		Finished Water Pump #4	
	3				
	4	Area Classification		Non-Hazardous	
	5	Line Size			
	6				
	7				
PROCESS CONDITIONS	8	Fluid		Potable Water	
	9	Min Pressure	Max Pressure	0 psi	200 psi
	10	Temperature		Ambient	
	11	Specific Gravity		1.0	
	12				
	13				
	14				
INDICATOR	15	Type		Bourdon Tube	
	16	Range		0-200 psi	
	17	Dial Size		4.5 inches	
	18	Dial Color		White	
	19	Process Connection		0.5 inch NPT	
	20	Mounting		Lower Stem	
	21	Movement Dampening		Glycerine	
	22	Case Material		Phenolic	
	23	Window Material		Acrylic	
	24				
	25	Blowout Protection		Case Back	
	26	Tube Materials		Stainless Steel	
	27	Socket Material		Stainless Steel	
	28				
DIAPHRAGM SEAL - ANNULAR SEAL	29	Type			
	30	Process Connection			
	31	Body Material			
	32	Diaphragm / Sleeve Material			
	33				
	34	Capillary Material			
	35	Capillary Length			
	36	Fill Fluid			
	37	Flushing Connection			
	38				
	39	Manufacturer			
	40	Model Number			
CALIBRATION	41				
	42	Vendor Calibration		Factory calibrate - Provide calibration certificate	
	43				
	44	Accuracy		0.5 Pct of Range	
	45				
OPTIONS	46	Tagging		Affix stainless steel tag with Tag Number	
	47				
	48				
PURCHASE	49	Manufacturer		Ashcroft	
	50	Model Number		1259	
	51				
	52				
	53				

P04	**Cutter Lateral WTP**
PRESSURE GAUGE	**November 9, 2017**
	PI-360-104-04

GENERAL	1	Tag Number	P&ID	PI-360-105-02	080-I-0014
	2	Loop Title		Backwash Pump #1	
	3				
	4	Area Classification		Non-Hazardous	
	5	Line Size			
	6				
	7				
PROCESS CONDITIONS	8	Fluid		Potable Water	
	9	Min Pressure	Max Pressure	0 psi	100 psi
	10	Temperature		Ambient	
	11	Specific Gravity		1.0	
	12				
	13				
	14				
INDICATOR	15	Type		Bourdon Tube	
	16	Range		0-160 psi	
	17	Dial Size		4.5 inches	
	18	Dial Color		White	
	19	Process Connection		0.5 inch NPT	
	20	Mounting		Lower Stem	
	21	Movement Dampening		Glycerine	
	22	Case Material		Phenolic	
	23	Window Material		Acrylic	
	24				
	25	Blowout Protection		Case Back	
	26	Tube Materials		Stainless Steel	
	27	Socket Material		Stainless Steel	
	28				
DIAPHRAGM SEAL - ANNULAR SEAL	29	Type			
	30	Process Connection			
	31	Body Material			
	32	Diaphragm / Sleeve Material			
	33				
	34	Capillary Material			
	35	Capillary Length			
	36	Fill Fluid			
	37	Flushing Connection			
	38				
	39	Manufacturer			
	40	Model Number			
CALIBRATION	41				
	42	Vendor Calibration		Factory calibrate - Provide calibration certificate	
	43				
	44	Accuracy		0.5 Pct of Range	
	45				
OPTIONS	46	Tagging		Affix stainless steel tag with Tag Number	
	47				
	48				
PURCHASE	49	Manufacturer		Ashcroft	
	50	Model Number		1259	
	51				
	52				
	53				

P04	**Cutter Lateral WTP**
PRESSURE GAUGE	**November 9, 2017**
	PI-360-105-02

GENERAL	1	Tag Number	P&ID	PI-360-205-02	080-I-0014
	2	Loop Title		Backwash Pump #2	
	3				
	4	Area Classification		Non-Hazardous	
	5	Line Size			
	6				
	7				
PROCESS CONDITIONS	8	Fluid		Potable Water	
	9	Min Pressure	Max Pressure	0 psi	100 psi
	10	Temperature		Ambient	
	11	Specific Gravity		1.0	
	12				
	13				
	14				
INDICATOR	15	Type		Bourdon Tube	
	16	Range		0-160 psi	
	17	Dial Size		4.5 inches	
	18	Dial Color		White	
	19	Process Connection		0.5 inch NPT	
	20	Mounting		Lower Stem	
	21	Movement Dampening		Glycerine	
	22	Case Material		Phenolic	
	23	Window Material		Acrylic	
	24				
	25	Blowout Protection		Case Back	
	26	Tube Materials		Stainless Steel	
	27	Socket Material		Stainless Steel	
	28				
DIAPHRAGM SEAL - ANNULAR SEAL	29	Type			
	30	Process Connection			
	31	Body Material			
	32	Diaphragm / Sleeve Material			
	33				
	34	Capillary Material			
	35	Capillary Length			
	36	Fill Fluid			
	37	Flushing Connection			
	38				
	39	Manufacturer			
	40	Model Number			
CALIBRATION	41				
	42	Vendor Calibration		Factory calibrate - Provide calibration certificate	
	43				
	44	Accuracy		0.5 Pct of Range	
	45				
OPTIONS	46	Tagging		Affix stainless steel tag with Tag Number	
	47				
	48				
PURCHASE	49	Manufacturer		Ashcroft	
	50	Model Number		1259	
	51				
	52				
	53				

P04	**Cutter Lateral WTP**
PRESSURE GAUGE	**November 9, 2017**
	PI-360-205-02

GENERAL	1	Tag Number	P&ID	PI-360-304-02	080-I-0014
	2	Loop Title		Finished water to Tank T3	
	3				
	4	Area Classification		Non-Hazardous	
	5	Line Size			
	6				
	7				
PROCESS CONDITIONS	8	Fluid		Potable Water	
	9	Min Pressure	Max Pressure	0 psi	100 psi
	10	Temperature		Ambient	
	11	Specific Gravity		1.0	
	12				
	13				
	14				
INDICATOR	15	Type		Bourdon Tube	
	16	Range		0-160 psi	
	17	Dial Size		4.5 inches	
	18	Dial Color		White	
	19	Process Connection		0.5 inch NPT	
	20	Mounting		Lower Stem	
	21	Movement Dampening		Glycerine	
	22	Case Material		Phenolic	
	23	Window Material		Acrylic	
	24				
	25	Blowout Protection		Case Back	
	26	Tube Materials		Stainless Steel	
	27	Socket Material		Stainless Steel	
	28				
DIAPHRAGM SEAL - ANNULAR SEAL	29	Type			
	30	Process Connection			
	31	Body Material			
	32	Diaphragm / Sleeve Material			
	33				
	34	Capillary Material			
	35	Capillary Length			
	36	Fill Fluid			
	37	Flushing Connection			
	38				
	39	Manufacturer			
	40	Model Number			
CALIBRATION	41				
	42	Vendor Calibration		Factory calibrate - Provide calibration certificate	
	43				
	44	Accuracy		0.5 Pct of Range	
	45				
OPTIONS	46	Tagging		Affix stainless steel tag with Tag Number	
	47				
	48				
PURCHASE	49	Manufacturer		Ashcroft	
	50	Model Number		1259	
	51				
	52				
	53				

P04	**Cutter Lateral WTP**
PRESSURE GAUGE	**November 9, 2017**
	PI-360-304-02

GENERAL	1	Tag Number	P&ID	PI-360-305-01	080-I-0014
	2	Loop Title		Finished water to Lab	
	3				
	4	Area Classification		Non-Hazardous	
	5	Line Size			
	6				
	7				
PROCESS CONDITIONS	8	Fluid		Potable Water	
	9	Min Pressure	Max Pressure	0 psi	100 psi
	10	Temperature		Ambient	
	11	Specific Gravity		1.0	
	12				
	13				
	14				
INDICATOR	15	Type		Bourdon Tube	
	16	Range		0-160 psi	
	17	Dial Size		4.5 inches	
	18	Dial Color		White	
	19	Process Connection		0.5 inch NPT	
	20	Mounting		Lower Stem	
	21	Movement Dampening		Glycerine	
	22	Case Material		Phenolic	
	23	Window Material		Acrylic	
	24				
	25	Blowout Protection		Case Back	
	26	Tube Materials		Stainless Steel	
	27	Socket Material		Stainless Steel	
	28				
DIAPHRAGM SEAL - ANNULAR SEAL	29	Type			
	30	Process Connection			
	31	Body Material			
	32	Diaphragm / Sleeve Material			
	33				
	34	Capillary Material			
	35	Capillary Length			
	36	Fill Fluid			
	37	Flushing Connection			
	38				
	39	Manufacturer			
	40	Model Number			
CALIBRATION	41				
	42	Vendor Calibration		Factory calibrate - Provide calibration certificate	
	43				
	44	Accuracy		0.5 Pct of Range	
	45				
OPTIONS	46	Tagging		Affix stainless steel tag with Tag Number	
	47				
	48				
PURCHASE	49	Manufacturer		Ashcroft	
	50	Model Number		1259	
	51				
	52				
	53				

P04	**Cutter Lateral WTP**
PRESSURE GAUGE	**November 9, 2017**
	PI-360-305-01

GENERAL	1	Tag Number	P&ID	PI-420-101-02	080-I-0016
	2	Loop Title		Sludge Transfer Pump 1	
	3				
	4	Area Classification		Non-Hazardous	
	5	Line Size			
	6				
	7				
PROCESS CONDITIONS	8	Fluid		Sludge	
	9	Min Pressure	Max Pressure	0 psi	100 psi
	10	Temperature		Ambient	
	11	Specific Gravity		1.0	
	12				
	13				
	14				
INDICATOR	15	Type		Bourdon Tube	
	16	Range		0-160 psi	
	17	Dial Size		4.5 inches	
	18	Dial Color		White	
	19	Process Connection		0.5 inch NPT	
	20	Mounting		Lower Stem	
	21	Movement Dampening		Glycerine	
	22	Case Material		Phenolic	
	23	Window Material		Acrylic	
	24				
	25	Blowout Protection		Case Back	
	26	Tube Materials		Stainless Steel	
	27	Socket Material		Stainless Steel	
	28				
DIAPHRAGM SEAL - ANNULAR SEAL	29	Type			
	30	Process Connection			
	31	Body Material			
	32	Diaphragm / Sleeve Material		PE-420-101-02 (SEE P06)	
	33				
	34	Capillary Material			
	35	Capillary Length			
	36	Fill Fluid			
	37	Flushing Connection			
	38				
	39	Manufacturer			
	40	Model Number			
CALIBRATION	41				
	42	Vendor Calibration		Factory calibrate - Provide calibration certificate	
	43				
	44	Accuracy		0.5 Pct of Range	
	45				
OPTIONS	46	Tagging		Affix stainless steel tag with Tag Number	
	47				
	48				
PURCHASE	49	Manufacturer		Ashcroft	
	50	Model Number		1259	
	51				
	52				
	53				

P04	**Cutter Lateral WTP**
PRESSURE GAUGE	**November 9, 2017**
	PI-420-101-02

GENERAL	1	Tag Number	P&ID	PI-420-201-02	080-I-0016
	2	Loop Title		Sludge Transfer Pump 2	
	3				
	4	Area Classification		Non-Hazardous	
	5	Line Size			
	6				
	7				
PROCESS CONDITIONS	8	Fluid		Sludge	
	9	Min Pressure	Max Pressure	0 psi	100 psi
	10	Temperature		Ambient	
	11	Specific Gravity		1.0	
	12				
	13				
	14				
INDICATOR	15	Type		Bourdon Tube	
	16	Range		0-160 psi	
	17	Dial Size		4.5 inches	
	18	Dial Color		White	
	19	Process Connection		0.5 inch NPT	
	20	Mounting		Lower Stem	
	21	Movement Dampening		Glycerine	
	22	Case Material		Phenolic	
	23	Window Material		Acrylic	
	24				
	25	Blowout Protection		Case Back	
	26	Tube Materials		Stainless Steel	
	27	Socket Material		Stainless Steel	
	28				
DIAPHRAGM SEAL - ANNULAR SEAL	29	Type			
	30	Process Connection			
	31	Body Material			
	32	Diaphragm / Sleeve Material		PE-420-201-02 (SEE P06)	
	33				
	34	Capillary Material			
	35	Capillary Length			
	36	Fill Fluid			
	37	Flushing Connection			
	38				
	39	Manufacturer			
	40	Model Number			
CALIBRATION	41				
	42	Vendor Calibration		Factory calibrate - Provide calibration certificate	
	43				
	44	Accuracy		0.5 Pct of Range	
	45				
OPTIONS	46	Tagging		Affix stainless steel tag with Tag Number	
	47				
	48				
PURCHASE	49	Manufacturer		Ashcroft	
	50	Model Number		1259	
	51				
	52				
	53				

P04	**Cutter Lateral WTP**
PRESSURE GAUGE	**November 9, 2017**
	PI-420-201-02

GENERAL	1	Tag Number	P&ID	PI-460-100-01	080-I-0017
	2	Loop Title		EVD Pump 1	
	3				
	4	Area Classification		Non-Hazardous	
	5	Line Size			
	6				
	7				
PROCESS CONDITIONS	8	Fluid		Non Potable Water	
	9	Min Pressure	Max Pressure	0 psi	100 psi
	10	Temperature		Ambient	
	11	Specific Gravity		1.0	
	12				
	13				
	14				
INDICATOR	15	Type		Bourdon Tube	
	16	Range		0-160 psi	
	17	Dial Size		4.5 inches	
	18	Dial Color		White	
	19	Process Connection		0.5 inch NPT	
	20	Mounting		Lower Stem	
	21	Movement Dampening		Glycerine	
	22	Case Material		Phenolic	
	23	Window Material		Acrylic	
	24				
	25	Blowout Protection		Case Back	
	26	Tube Materials		Stainless Steel	
	27	Socket Material		Stainless Steel	
	28				
DIAPHRAGM SEAL - ANNULAR SEAL	29	Type			
	30	Process Connection			
	31	Body Material			
	32	Diaphragm / Sleeve Material			
	33				
	34	Capillary Material			
	35	Capillary Length			
	36	Fill Fluid			
	37	Flushing Connection			
	38				
	39	Manufacturer			
	40	Model Number			
CALIBRATION	41				
	42	Vendor Calibration		Factory calibrate - Provide calibration certificate	
	43				
	44	Accuracy		0.5 Pct of Range	
	45				
OPTIONS	46	Tagging		Affix stainless steel tag with Tag Number	
	47				
	48				
PURCHASE	49	Manufacturer		Ashcroft	
	50	Model Number		1259	
	51				
	52				
	53				

P04	**Cutter Lateral WTP**
PRESSURE GAUGE	**November 9, 2017**
	PI-460-100-01

GENERAL	1	Tag Number	P&ID	PI-460-100-02	080-I-0017
	2	Loop Title		EVD Pump 2	
	3				
	4	Area Classification		Non-Hazardous	
	5	Line Size			
	6				
	7				
PROCESS CONDITIONS	8	Fluid		Non Potable Water	
	9	Min Pressure	Max Pressure	0 psi	100 psi
	10	Temperature		Ambient	
	11	Specific Gravity		1.0	
	12				
	13				
	14				
INDICATOR	15	Type		Bourdon Tube	
	16	Range		0-160 psi	
	17	Dial Size		4.5 inches	
	18	Dial Color		White	
	19	Process Connection		0.5 inch NPT	
	20	Mounting		Lower Stem	
	21	Movement Dampening		Glycerine	
	22	Case Material		Phenolic	
	23	Window Material		Acrylic	
	24				
	25	Blowout Protection		Case Back	
	26	Tube Materials		Stainless Steel	
	27	Socket Material		Stainless Steel	
	28				
DIAPHRAGM SEAL - ANNULAR SEAL	29	Type			
	30	Process Connection			
	31	Body Material			
	32	Diaphragm / Sleeve Material			
	33				
	34	Capillary Material			
	35	Capillary Length			
	36	Fill Fluid			
	37	Flushing Connection			
	38				
	39	Manufacturer			
	40	Model Number			
CALIBRATION	41				
	42	Vendor Calibration		Factory calibrate - Provide calibration certificate	
	43				
	44	Accuracy		0.5 Pct of Range	
	45				
OPTIONS	46	Tagging		Affix stainless steel tag with Tag Number	
	47				
	48				
PURCHASE	49	Manufacturer		Ashcroft	
	50	Model Number		1259	
	51				
	52				
	53				

P04	**Cutter Lateral WTP**
PRESSURE GAUGE	**November 9, 2017**
	PI-460-100-02

GENERAL	1	Tag Number	P&ID	PI-460-100-03	080-I-0017
	2	Loop Title		EVD Pump 3	
	3				
	4	Area Classification		Non-Hazardous	
	5	Line Size			
	6				
	7				
PROCESS CONDITIONS	8	Fluid		Non Potable Water	
	9	Min Pressure	Max Pressure	0 psi	100 psi
	10	Temperature		Ambient	
	11	Specific Gravity		1.0	
	12				
	13				
	14				
INDICATOR	15	Type		Bourdon Tube	
	16	Range		0-160 psi	
	17	Dial Size		4.5 inches	
	18	Dial Color		White	
	19	Process Connection		0.5 inch NPT	
	20	Mounting		Lower Stem	
	21	Movement Dampening		Glycerine	
	22	Case Material		Phenolic	
	23	Window Material		Acrylic	
	24				
	25	Blowout Protection		Case Back	
	26	Tube Materials		Stainless Steel	
	27	Socket Material		Stainless Steel	
	28				
DIAPHRAGM SEAL - ANNULAR SEAL	29	Type			
	30	Process Connection			
	31	Body Material			
	32	Diaphragm / Sleeve Material			
	33				
	34	Capillary Material			
	35	Capillary Length			
	36	Fill Fluid			
	37	Flushing Connection			
	38				
	39	Manufacturer			
	40	Model Number			
CALIBRATION	41				
	42	Vendor Calibration		Factory calibrate - Provide calibration certificate	
	43				
	44	Accuracy		0.5 Pct of Range	
	45				
OPTIONS	46	Tagging		Affix stainless steel tag with Tag Number	
	47				
	48				
PURCHASE	49	Manufacturer		Ashcroft	
	50	Model Number		1259	
	51				
	52				
	53				

P04	**Cutter Lateral WTP**
PRESSURE GAUGE	**November 9, 2017**
	PI-460-100-03

GENERAL	1	Tag Number	P&ID	PIT-300-105-04	080-I-0011
	2	Loop Title		GAC Supply Pumps Combined Discharge	
	3	Area Classification		Non-Hazardous	
	4				
	5				
PROCESS CONDITIONS	6	Fluid		Plant Effluent	
	7	Min Pressure	Max Pressure		
	8	Temperature			
	9	Specific Gravity			
	10				
	11				
	12	Location		Outside	
ELEMENT	13	Element Type		Metallic Welded Diaphragm	
	14	Element Material			
	15	Body Rating			
	16	Instrument Body Material		AISI 316L	
	17	Wetted Materials		AISI 316L	
	18	Process Connection		Direct Pipe Mount, 0.5 inch FNPT	
	19	Measurable Limits			
	20	Ambient Temperature Limits		-40 degF to 185 degF	
	21	Process Temperature Limits		-40 degF to 250 degF	
	22	Wetted O-Ring Material			
ANNULAR or DIAPHRAGM SEAL	23	Type			
	24	Tag			
	25	Process Connection			
	26	Body Material			
	27	Diaphragm / Sleeve Material			
	28	Capillary Material			
	29	Fill Fluid			
	30	Flushing Connection			
	31	Manufacturer			
	32	Model Number			
TRANSMITTER	33	Mounting		Integral	
	34	Tag		NA	
	35	Enclosure NEMA Rating		NEMA 46P	
	36	Power Supply	Voltage	2-Wire	24 VDC
	37	Output Signal		4-20 mA	
	38	Communication Protocol		HART	
	39	Range			
CALIBRATION	40	Calibrated Range		0-30 psi	
	41	Vendor Calibration		Factory calibrate - Provide calibration certificate	
	42	Zero Elevated or Suppressed			
	43	Zero Reference			
	44	Accuracy	Repeatability	0.075 Pct of Span	
	45				
OPTIONS	46	Multi-Valve Manifold		No	
	47	Tagging		Affix stainless steel tag with Tag Number	
	48	Mounting Bracket			
	49	Sun Shield			
PURCHASE	50	Manufacturer		Endress + Hauser	
	51	Model Number		Cerebar S PMP71	
	52				
	53	Multi-Valve Manifold Model Number		NA	

P09	**Cutter Lateral WTP**
PRESSURE TRANSMITTER	**November 9, 2017**
	PIT-300-105-04

GENERAL	1	Tag Number	P&ID	PIT-360-102-03	080-I-0013
	2	Loop Title		Domestic Water Supply Combined Discharge to W1	
	3	Area Classification		Non-Hazardous	
	4				
	5				
PROCESS CONDITIONS	6	Fluid		Plant Effluent	
	7	Min Pressure	Max Pressure		
	8	Temperature			
	9	Specific Gravity			
	10				
	11				
	12	Location		Outside	
ELEMENT	13	Element Type		Metallic Welded Diaphragm	
	14	Element Material			
	15	Body Rating			
	16	Instrument Body Material		AISI 316L	
	17	Wetted Materials		AISI 316L	
	18	Process Connection		Direct Pipe Mount, 0.5 inch FNPT	
	19	Measurable Limits			
	20	Ambient Temperature Limits		-40 degF to 185 degF	
	21	Process Temperature Limits		-40 degF to 250 degF	
	22	Wetted O-Ring Material			
ANNULAR or DIAPHRAGM SEAL	23	Type			
	24	Tag			
	25	Process Connection			
	26	Body Material			
	27	Diaphragm / Sleeve Material			
	28	Capillary Material			
	29	Fill Fluid			
	30	Flushing Connection			
	31	Manufacturer			
	32	Model Number			
TRANSMITTER	33	Mounting		Integral	
	34	Tag		NA	
	35	Enclosure NEMA Rating		NEMA 46P	
	36	Power Supply	Voltage	2-Wire	24 VDC
	37	Output Signal		4-20 mA	
	38	Communication Protocol		HART	
	39	Range			
CALIBRATION	40	Calibrated Range		0-30 psi	
	41	Vendor Calibration		Factory calibrate - Provide calibration certificate	
	42	Zero Elevated or Suppressed			
	43	Zero Reference			
	44	Accuracy	Repeatability	0.075 Pct of Span	
	45				
OPTIONS	46	Multi-Valve Manifold		No	
	47	Tagging		Affix stainless steel tag with Tag Number	
	48	Mounting Bracket			
	49	Sun Shield			
PURCHASE	50	Manufacturer		Endress + Hauser	
	51	Model Number		Cerebar S PMP71	
	52				
	53	Multi-Valve Manifold Model Number		NA	

P09	**Cutter Lateral WTP**
PRESSURE TRANSMITTER	**November 9, 2017**
	PIT-360-102-03

GENERAL	1	Tag Number	P&ID	PIT-360-304-03	080-I-0014
	2	Loop Title		Finished Water To Tank T3	
	3	Area Classification		Non-Hazardous	
	4				
	5				
PROCESS CONDITIONS	6	Fluid		Plant Effluent	
	7	Min Pressure	Max Pressure		
	8	Temperature			
	9	Specific Gravity			
	10				
	11				
	12	Location		Outside	
ELEMENT	13	Element Type		Metallic Welded Diaphragm	
	14	Element Material			
	15	Body Rating			
	16	Instrument Body Material		AISI 316L	
	17	Wetted Materials		AISI 316L	
	18	Process Connection		Direct Pipe Mount, 0.5 inch FNPT	
	19	Measurable Limits			
	20	Ambient Temperature Limits		-40 degF to 185 degF	
	21	Process Temperature Limits		-40 degF to 250 degF	
	22	Wetted O-Ring Material			
ANNULAR or DIAPHRAGM SEAL	23	Type			
	24	Tag			
	25	Process Connection			
	26	Body Material			
	27	Diaphragm / Sleeve Material			
	28	Capillary Material			
	29	Fill Fluid			
	30	Flushing Connection			
	31	Manufacturer			
	32	Model Number			
TRANSMITTER	33	Mounting		Integral	
	34	Tag		NA	
	35	Enclosure NEMA Rating		NEMA 46P	
	36	Power Supply	Voltage	2-Wire	24 VDC
	37	Output Signal		4-20 mA	
	38	Communication Protocol		HART	
	39	Range			
CALIBRATION	40	Calibrated Range		0-30 psi	
	41	Vendor Calibration		Factory calibrate - Provide calibration certificate	
	42	Zero Elevated or Suppressed			
	43	Zero Reference			
	44	Accuracy	Repeatability	0.075 Pct of Span	
	45				
OPTIONS	46	Multi-Valve Manifold		No	
	47	Tagging		Affix stainless steel tag with Tag Number	
	48	Mounting Bracket			
	49	Sun Shield			
PURCHASE	50	Manufacturer		Endress + Hauser	
	51	Model Number		Cerebar S PMP71	
	52				
	53	Multi-Valve Manifold Model Number		NA	

P09	**Cutter Lateral WTP**
PRESSURE TRANSMITTER	**November 9, 2017**
	PIT-360-304-03

GENERAL	1	Tag Number	P&ID	PIT-360-305-01	080-I-0014
	2	Loop Title		Finished Water To Lab	
	3	Area Classification		Non-Hazardous	
	4				
	5				
PROCESS CONDITIONS	6	Fluid		Plant Effluent	
	7	Min Pressure	Max Pressure		
	8	Temperature			
	9	Specific Gravity			
	10				
	11				
	12	Location		Outside	
ELEMENT	13	Element Type		Metallic Welded Diaphragm	
	14	Element Material			
	15	Body Rating			
	16	Instrument Body Material		AISI 316L	
	17	Wetted Materials		AISI 316L	
	18	Process Connection		Direct Pipe Mount, 0.5 inch FNPT	
	19	Measurable Limits			
	20	Ambient Temperature Limits		-40 degF to 185 degF	
	21	Process Temperature Limits		-40 degF to 250 degF	
	22	Wetted O-Ring Material			
ANNULAR or DIAPHRAGM SEAL	23	Type			
	24	Tag			
	25	Process Connection			
	26	Body Material			
	27	Diaphragm / Sleeve Material			
	28	Capillary Material			
	29	Fill Fluid			
	30	Flushing Connection			
	31	Manufacturer			
	32	Model Number			
TRANSMITTER	33	Mounting		Integral	
	34	Tag		NA	
	35	Enclosure NEMA Rating		NEMA 46P	
	36	Power Supply	Voltage	2-Wire	24 VDC
	37	Output Signal		4-20 mA	
	38	Communication Protocol		HART	
	39	Range			
CALIBRATION	40	Calibrated Range		0-30 psi	
	41	Vendor Calibration		Factory calibrate - Provide calibration certificate	
	42	Zero Elevated or Suppressed			
	43	Zero Reference			
	44	Accuracy	Repeatability	0.075 Pct of Span	
	45				
OPTIONS	46	Multi-Valve Manifold		No	
	47	Tagging		Affix stainless steel tag with Tag Number	
	48	Mounting Bracket			
	49	Sun Shield			
PURCHASE	50	Manufacturer		Endress + Hauser	
	51	Model Number		Cerebar S PMP71	
	52				
	53	Multi-Valve Manifold Model Number		NA	

P09	**Cutter Lateral WTP**
PRESSURE TRANSMITTER	**November 9, 2017**
	PIT-360-305-01

GENERAL	1	Tag Number	P&ID	AIT-300-101-01	080-I-0005
	2	Loop Title		Filter 1 Effluent Turbidity	
	3				
	4	Area Classification		Non-Hazardous	
	5				
	6				
	7				
PROCESS CONDITIONS	8	Fluid		Filter Effluent	
	9	Pressure		7 - 10 PSI	
	10	Temperature		45 - 60 degF	
	11	Specific Gravity		1.0	
	12				
	13				
	14				
ELEMENT	15	Element Tag		AE-300-101-01	
	16	Element Type		Nephelometric	
	17	Range		0.001 to 100 NTU	
	18	Process Connection		1/4" Tubing	
	19	Drain		1/2" NPT	
	20	Mounting		Wall	
	21	Cable Length		6 ft	
	22				
	23	Ambient Temperature Limits		-4 degF to 140 degF	
	24	Process Temperature Limits		32 degF to 100 degF	
	25				
	26				
	27				
	28				
	29				
	30				
	31				
	32				
	33				
TRANSMITTER	34	Transmitter Tag		AIT-300-101-01	
	35	Mounting		Wall	
	36	Enclosure NEMA Rating		NEMA 4X	
	37	Power Supply	Voltage	4-Wire	120V AC (Hardwired)
	38	Output Signal	Quantity	4-20mAdc	2
	39	Communication Protocol			
CALIBRATION	40	Calibrated Range		.01-1.0 NTU	
	41	Vendor Calibration		Field calibrate - Provide calibration certificate	
	42	Accuracy	Repeatability	2.0 Pct of Reading	1.0 Pct of Reading
	43				
OPTIONS	44	Tagging		Affix stainless steel tag with Tag Number	
	45	Sun Shield		No	
	46	Mounting Kit		No	
	47	Calibration Cylinder		Required	
	48	Standard for 20 NTU		Required	
PURCHASE	49	Manufacturer		HACH	
	50	Element/Transmitter Models		1720E (Element), SC200 single channel (Transmitter)	
	51	Element/Transmitter Ordering Part Number		2978100 (Kit to Order includes element and transmitter)	
	52	Stainless Steel Tag Ordering Part Number		891901	
	53				

A16	**Cutter Lateral WTP**
TURBIDITY ANALYZER AND TRANSMITTER	**AIT-300-101-01**

GENERAL	1	Tag Number	P&ID	AIT-300-201-01	080-I-0006
	2	Loop Title		Filter 2 Effluent Turbidity	
	3				
	4	Area Classification		Non-Hazardous	
	5				
	6				
	7				
PROCESS CONDITIONS	8	Fluid		Filter Effluent	
	9	Pressure		7 - 10 PSI	
	10	Temperature		45 - 60 degF	
	11	Specific Gravity		1.0	
	12				
	13				
	14				
ELEMENT	15	Element Tag		AE-300-201-01	
	16	Element Type		Nephelometric	
	17	Range		0.001 to 100 NTU	
	18	Process Connection		1/4" Tubing	
	19	Drain		1/2" NPT	
	20	Mounting		Wall	
	21	Cable Length		6 ft	
	22				
	23	Ambient Temperature Limits		-4 degF to 140 degF	
	24	Process Temperature Limits		32 degF to 100 degF	
	25				
	26				
	27				
	28				
	29				
	30				
	31				
	32				
	33				
TRANSMITTER	34	Transmitter Tag		AIT-300-201-01	
	35	Mounting		Wall	
	36	Enclosure NEMA Rating		NEMA 4X	
	37	Power Supply	Voltage	4-Wire	120V AC (Hardwired)
	38	Output Signal	Quantity	4-20mAdc	2
	39	Communication Protocol			
CALIBRATION	40	Calibrated Range		.01-1.0 NTU	
	41	Vendor Calibration		Field calibrate - Provide calibration certificate	
	42	Accuracy	Repeatability	2.0 Pct of Reading	1.0 Pct of Reading
	43				
OPTIONS	44	Tagging		Affix stainless steel tag with Tag Number	
	45	Sun Shield		No	
	46	Mounting Kit		No	
	47	Calibration Cylinder		Required	
	48	Standard for 20 NTU		Required	
PURCHASE	49	Manufacturer		HACH	
	50	Element/Transmitter Models		1720E (Element), SC200 single channel (Transmitter)	
	51	Element/Transmitter Ordering Part Number		2978100 (Kit to Order includes element and transmitter)	
	52	Stainless Steel Tag Ordering Part Number		891901	
	53				

A16	**Cutter Lateral WTP**
TURBIDITY ANALYZER AND TRANSMITTER	**AIT-300-201-01**

GENERAL	1	Tag Number	P&ID	AIT-300-301-01	080-I-0007
	2	Loop Title		Filter 3 Effluent Turbidity	
	3				
	4	Area Classification		Non-Hazardous	
	5				
	6				
	7				
PROCESS CONDITIONS	8	Fluid		Filter Effluent	
	9	Pressure		7 - 10 PSI	
	10	Temperature		45 - 60 degF	
	11	Specific Gravity		1.0	
	12				
	13				
	14				
ELEMENT	15	Element Tag		AE-300-301-01	
	16	Element Type		Nephelometric	
	17	Range		0.001 to 100 NTU	
	18	Process Connection		1/4" Tubing	
	19	Drain		1/2" NPT	
	20	Mounting		Wall	
	21	Cable Length		6 ft	
	22				
	23	Ambient Temperature Limits		-4 degF to 140 degF	
	24	Process Temperature Limits		32 degF to 100 degF	
	25				
	26				
	27				
	28				
	29				
	30				
	31				
	32				
	33				
TRANSMITTER	34	Transmitter Tag		AIT-300-301-01	
	35	Mounting		Wall	
	36	Enclosure NEMA Rating		NEMA 4X	
	37	Power Supply	Voltage	4-Wire	120V AC (Hardwired)
	38	Output Signal	Quantity	4-20mAdc	2
	39	Communication Protocol			
CALIBRATION	40	Calibrated Range		.01-1.0 NTU	
	41	Vendor Calibration		Field calibrate - Provide calibration certificate	
	42	Accuracy	Repeatability	2.0 Pct of Reading	1.0 Pct of Reading
	43				
OPTIONS	44	Tagging		Affix stainless steel tag with Tag Number	
	45	Sun Shield		No	
	46	Mounting Kit		No	
	47	Calibration Cylinder		Required	
	48	Standard for 20 NTU		Required	
PURCHASE	49	Manufacturer		HACH	
	50	Element/Transmitter Models		1720E (Element), SC200 single channel (Transmitter)	
	51	Element/Transmitter Ordering Part Number		2978100 (Kit to Order includes element and transmitter)	
	52	Stainless Steel Tag Ordering Part Number		891901	
	53				

A16	**Cutter Lateral WTP**
TURBIDITY ANALYZER AND TRANSMITTER	**AIT-300-301-01**

GENERAL	1	Tag Number	P&ID	AIT-300-401-01	080-I-0008
	2	Loop Title		Filter 4 Effluent Turbidity	
	3				
	4	Area Classification		Non-Hazardous	
	5				
	6				
	7				
PROCESS CONDITIONS	8	Fluid		Filter Effluent	
	9	Pressure		7 - 10 PSI	
	10	Temperature		45 - 60 degF	
	11	Specific Gravity		1.0	
	12				
	13				
	14				
ELEMENT	15	Element Tag		AE-300-401-01	
	16	Element Type		Nephelometric	
	17	Range		0.001 to 100 NTU	
	18	Process Connection		1/4" Tubing	
	19	Drain		1/2" NPT	
	20	Mounting		Wall	
	21	Cable Length		6 ft	
	22				
	23	Ambient Temperature Limits		-4 degF to 140 degF	
	24	Process Temperature Limits		32 degF to 100 degF	
	25				
	26				
	27				
	28				
	29				
	30				
	31				
	32				
	33				
TRANSMITTER	34	Transmitter Tag		AIT-300-401-01	
	35	Mounting		Wall	
	36	Enclosure NEMA Rating		NEMA 4X	
	37	Power Supply	Voltage	4-Wire	120V AC (Hardwired)
	38	Output Signal	Quantity	4-20mAdc	2
	39	Communication Protocol			
CALIBRATION	40	Calibrated Range		.01-1.0 NTU	
	41	Vendor Calibration		Field calibrate - Provide calibration certificate	
	42	Accuracy	Repeatability	2.0 Pct of Reading	1.0 Pct of Reading
	43				
OPTIONS	44	Tagging		Affix stainless steel tag with Tag Number	
	45	Sun Shield		No	
	46	Mounting Kit		No	
	47	Calibration Cylinder		Required	
	48	Standard for 20 NTU		Required	
PURCHASE	49	Manufacturer		HACH	
	50	Element/Transmitter Models		1720E (Element), SC200 single channel (Transmitter)	
	51	Element/Transmitter Ordering Part Number		2978100 (Kit to Order includes element and transmitter)	
	52	Stainless Steel Tag Ordering Part Number		891901	
	53				

A16	**Cutter Lateral WTP**
TURBIDITY ANALYZER AND TRANSMITTER	**AIT-300-401-01**

GENERAL	1	Tag Number	P&ID	AIT-300-501-01A	080-I-0010
	2	Loop Title		Filter Effluent Turbidity	
	3				
	4	Area Classification		Non-Hazardous	
	5				
	6				
	7				
PROCESS CONDITIONS	8	Fluid		Filter Effluent	
	9	Pressure		7 - 10 PSI	
	10	Temperature		45 - 60 degF	
	11	Specific Gravity		1.0	
	12				
	13				
	14				
ELEMENT	15	Element Tag		AE-300-501-01A	
	16	Element Type		Nephelometric	
	17	Range		0.001 to 100 NTU	
	18	Process Connection		1/4" Tubing	
	19	Drain		1/2" NPT	
	20	Mounting		Wall	
	21	Cable Length		6 ft	
	22				
	23	Ambient Temperature Limits		-4 degF to 140 degF	
	24	Process Temperature Limits		32 degF to 100 degF	
	25				
	26				
	27				
	28				
	29				
	30				
	31				
	32				
	33				
TRANSMITTER	34	Transmitter Tag		AIT-300-501-01A	
	35	Mounting		Wall	
	36	Enclosure NEMA Rating		NEMA 4X	
	37	Power Supply	Voltage	4-Wire	120V AC (Hardwired)
	38	Output Signal	Quantity	4-20mAdc	2
	39	Communication Protocol			
CALIBRATION	40	Calibrated Range		.01-1.0 NTU	
	41	Vendor Calibration		Field calibrate - Provide calibration certificate	
	42	Accuracy	Repeatability	2.0 Pct of Reading	1.0 Pct of Reading
	43				
OPTIONS	44	Tagging		Affix stainless steel tag with Tag Number	
	45	Sun Shield		No	
	46	Mounting Kit		No	
	47	Calibration Cylinder		Required	
	48	Standard for 20 NTU		Required	
PURCHASE	49	Manufacturer		HACH	
	50	Element/Transmitter Models		1720E (Element), SC200 single channel (Transmitter)	
	51	Element/Transmitter Ordering Part Number		2978100 (Kit to Order includes element and transmitter)	
	52	Stainless Steel Tag Ordering Part Number		891901	
	53				

A16	**Cutter Lateral WTP**
TURBIDITY ANALYZER AND TRANSMITTER	**AIT-300-501-01A**

GENERAL	1	Tag Number	P&ID	AIT-300-601-01A	080-I-0010
	2	Loop Title		GAC Effluent Turbidity	
	3				
	4	Area Classification		Non-Hazardous	
	5				
	6				
	7				
PROCESS CONDITIONS	8	Fluid		Filter Effluent	
	9	Pressure		7 - 10 PSI	
	10	Temperature		45 - 60 degF	
	11	Specific Gravity		1.0	
	12				
	13				
	14				
ELEMENT	15	Element Tag		AE-300-601-01A	
	16	Element Type		Nephelometric	
	17	Range		0.001 to 100 NTU	
	18	Process Connection		1/4" Tubing	
	19	Drain		1/2" NPT	
	20	Mounting		Wall	
	21	Cable Length		6 ft	
	22				
	23	Ambient Temperature Limits		-4 degF to 140 degF	
	24	Process Temperature Limits		32 degF to 100 degF	
	25				
	26				
	27				
	28				
	29				
	30				
	31				
	32				
	33				
TRANSMITTER	34	Transmitter Tag		AIT-300-601-01A	
	35	Mounting		Wall	
	36	Enclosure NEMA Rating		NEMA 4X	
	37	Power Supply	Voltage	4-Wire	120V AC (Hardwired)
	38	Output Signal	Quantity	4-20mAdc	2
	39	Communication Protocol			
CALIBRATION	40	Calibrated Range		.01-1.0 NTU	
	41	Vendor Calibration		Field calibrate - Provide calibration certificate	
	42	Accuracy	Repeatability	2.0 Pct of Reading	1.0 Pct of Reading
	43				
OPTIONS	44	Tagging		Affix stainless steel tag with Tag Number	
	45	Sun Shield		No	
	46	Mounting Kit		No	
	47	Calibration Cylinder		Required	
	48	Standard for 20 NTU		Required	
PURCHASE	49	Manufacturer		HACH	
	50	Element/Transmitter Models		1720E (Element), SC200 single channel (Transmitter)	
	51	Element/Transmitter Ordering Part Number		2978100 (Kit to Order includes element and transmitter)	
	52	Stainless Steel Tag Ordering Part Number		891901	
	53				

A16	**Cutter Lateral WTP**
TURBIDITY ANALYZER AND TRANSMITTER	**AIT-300-601-01A**

GENERAL	1	Tag Number	P&ID	AIT-900-100-01	080-I-0030
	2	Loop Title		Tank T3 Residual Chlorine Analyzer	
	3				
	4	Area Classification		Non-Hazardous	
	5				
	6				
	7				
PROCESS CONDITIONS	8	Fluid		Finished Water	
	9	Pressure		1.5 PSI	
	10	Temperature		45 - 60 degF	
	11	Specific Gravity	Viscosity	1.0	
	12				
	13				
	14				
ELEMENT	15	Element Type		Colorimetric	
	16	Element Measurement		Free Chlorine	
	17	Detection Limit		0.04 mg/l	
	18				
	19	Process Connection		0.25 inch	
	20	Min Sample Flow	Max Sample Flow	200 mL/Min	500 mL/Min
	21	Min Sample Press	Max Sample Press	1 PSI	5 PSI
	22				
	23	Ambient Temperature Limits		32 degF to 104 degF	
	24	Process Temperature Limits		40 degF to 104 degF	
	25				
	26				
	27				
	28				
	29				
	30				
	31				
	32				
	33				
TRANSMITTER	34	Transmitter Tag		AIT-900-100- 01	
	35	Mounting		Wall	
	36	Enclosure NEMA Rating		IP62	
	37	Power Supply	Voltage	4-Wire	120 VAC Hardwired
	38	Output Signal	Quantity	4-20mAdc	1
	39				
	40	Range		0 - 5 mg/l	
CALIBRATION	41	Calibrated Range		0 - 5 mg/l	
	42	Vendor Calibration		Field calibrate - Provide calibration certificate	
	43	Accuracy	Repeatability	5.0 Pct of Range	0.01 mg/l
	44				
OPTIONS	45	Tagging		Affix stainless steel tag with Tag Number	
	46	Reagent Kit		Required	
	47	Sample Conditioning Kit		Required	
	48	Maintenance Kit		NOT Required with instrument purchase	
PURCHASE	49	Manufacturer		HACH	
	50	Model Number		5440001 (CL17 and Sample Conditioning Kit)	
	51	Reagent Kit	Quantity	2556900	2
	52	Stainless Steel Tag Ordering Part Number		891901	
	53				

A24	**Cutter Lateral WTP**
CHLORINE RESIDUAL ANALYZER AND TRANSMITTER	**AIT-900-100-01**

GENERAL	1	Tag Number	P&ID	AIT-900-100-02	080-I-0030
	2	Loop Title		Tank T3 Residual Chlorine Analyzer	
	3				
	4	Area Classification		Non-Hazardous	
	5				
	6				
	7				
PROCESS CONDITIONS	8	Fluid		Finished Water	
	9	Pressure		1.5 PSI	
	10	Temperature		45 - 60 degF	
	11	Specific Gravity	Viscosity	1.0	
	12				
	13				
	14				
ELEMENT	15	Element Type		Colorimetric	
	16	Element Measurement		Free Chlorine	
	17	Detection Limit		0.04 mg/l	
	18				
	19	Process Connection		0.25 inch	
	20	Min Sample Flow	Max Sample Flow	200 mL/Min	500 mL/Min
	21	Min Sample Press	Max Sample Press	1 PSI	5 PSI
	22				
	23	Ambient Temperature Limits		32 degF to 104 degF	
	24	Process Temperature Limits		40 degF to 104 degF	
	25				
	26				
	27				
	28				
	29				
	30				
	31				
	32				
	33				
TRANSMITTER	34	Transmitter Tag		AIT-900-100- 02	
	35	Mounting		Wall	
	36	Enclosure NEMA Rating		IP62	
	37	Power Supply	Voltage	4-Wire	120 VAC Hardwired
	38	Output Signal	Quantity	4-20mAdc	1
	39				
	40	Range		0 - 5 mg/l	
CALIBRATION	41	Calibrated Range		0 - 5 mg/l	
	42	Vendor Calibration		Field calibrate - Provide calibration certificate	
	43	Accuracy	Repeatability	5.0 Pct of Range	0.01 mg/l
	44				
OPTIONS	45	Tagging		Affix stainless steel tag with Tag Number	
	46	Reagent Kit		Required	
	47	Sample Conditioning Kit		Required	
	48	Maintenance Kit		NOT Required with instrument purchase	
PURCHASE	49	Manufacturer		HACH	
	50	Model Number		5440001 (CL17 and Sample Conditioning Kit)	
	51	Reagent Kit	Quantity	2556900	2
	52	Stainless Steel Tag Ordering Part Number		891901	
	53				

A24	**Cutter Lateral WTP**
CHLORINE RESIDUAL ANALYZER AND TRANSMITTER	**AIT-900-100-02**

GENERAL	1	Tag Number	P&ID	AIT-360-101-03	080-I-0013
	2	Loop Title		finished Water Residual Chlorine Analyzer	
	3				
	4	Area Classification		Non-Hazardous	
	5				
	6				
	7				
PROCESS CONDITIONS	8	Fluid		Finished Water	
	9	Pressure		1.5 PSI	
	10	Temperature		45 - 60 degF	
	11	Specific Gravity	Viscosity	1.0	
	12				
	13				
	14				
ELEMENT	15	Element Type		Colorimetric	
	16	Element Measurement		Free Chlorine	
	17	Detection Limit		0.04 mg/l	
	18				
	19	Process Connection		0.25 inch	
	20	Min Sample Flow	Max Sample Flow	200 mL/Min	500 mL/Min
	21	Min Sample Press	Max Sample Press	1 PSI	5 PSI
	22				
	23	Ambient Temperature Limits		32 degF to 104 degF	
	24	Process Temperature Limits		40 degF to 104 degF	
	25				
	26				
	27				
	28				
	29				
	30				
	31				
	32				
	33				
TRANSMITTER	34	Transmitter Tag		AIT-360-101-03	
	35	Mounting		Wall	
	36	Enclosure NEMA Rating		IP62	
	37	Power Supply	Voltage	4-Wire	120 VAC Hardwired
	38	Output Signal	Quantity	4-20mAdc	1
	39				
	40	Range		0 - 5 mg/l	
CALIBRATION	41	Calibrated Range		0 - 5 mg/l	
	42	Vendor Calibration		Field calibrate - Provide calibration certificate	
	43	Accuracy	Repeatability	5.0 Pct of Range	0.01 mg/l
	44				
OPTIONS	45	Tagging		Affix stainless steel tag with Tag Number	
	46	Reagent Kit		Required	
	47	Sample Conditioning Kit		Required	
	48	Maintenance Kit		NOT Required with instrument purchase	
PURCHASE	49	Manufacturer		HACH	
	50	Model Number		5440001 (CL17 and Sample Conditioning Kit)	
	51	Reagent Kit	Quantity	2556900	2
	52	Stainless Steel Tag Ordering Part Number		891901	
	53				

A24	**Cutter Lateral WTP**
CHLORINE RESIDUAL ANALYZER AND TRANSMITTER	**AIT-360-101-03**

SECTION 40 92 01
CONTROL PANELS

PART 1 GENERAL

1.01 WORK INCLUDED

A. This Section gives requirements for furnishing custom fabricated control panels based on diagrammatic control panel layouts and typical wiring diagrams provided by CH2M HILL.

1.02 RELATED SECTIONS

A. Related sections include the following:

1. Division 1, General Requirements.
2. Section 09 90 00, Painting and Coating.
3. Section 40 91 00, Instrumentation Components.
4. Section 40 92 05, Programmable Logic Controllers.
5. Section 40 92 06, Network and Computer Component.
6. Section 40 95 80, Fiber Optic Communication System.

1.03 REFERENCES

A. The following is a list of standards which may be referenced in this Section:

1. American National Standards Institute (ANSI).
2. ASTM International (ASTM):
   a. A182/A182M, Standard Specification for Forged or Rolled Alloy and Stainless Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service.
   b. A276, Standard Specification for Stainless Steel Bars and Shapes.
   c. A312/A312M, Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes.
   d. B32, Standard Specification for Solder Metal.
   e. B88, Standard Specification for Seamless Copper Water Tube.
3. Deutsche Industrie-Norm (DIN): VDE 0611, Specification for modular terminal blocks for connection of copper conductors up to 1,000V ac and up to 1,200V dc.
4. Institute of Electrical and Electronics Engineers, Inc. (IEEE): C62.41, Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits.

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5. The Instrument, Systems, and Automation Society (ISA):
    a. S5.1, Instrumentation Symbols and Identification.
    b. S50.1, Compatibility of Analog Signals for Electronic Industrial Process Instruments.
    c. TR20.00.01, Specification Forms for Process Measurement and Control Instruments, Part 1: General.
6. International Conference on Energy Conversion and Application (ICECA).
7. National Electrical Code (NEC).
8. National Electrical Manufacturers Association (NEMA):
    a. 250, Enclosures for Electrical Equipment (1,000 Volts Maximum).
    b. ICS 1, Industrial Control and Systems General Requirements.
9. National Fire Protection Association (NFPA):
    a. 79, Electrical Standard for Industrial Machinery.
    b. 820, Standard for Fire Protection in Wastewater Treatment and Collection Facilities.
10. Underwriters Laboratories, Inc. (UL): 508A, Standard for Safety, Industrial Control Panels.

1.04 DEFINITIONS

A. Abbreviations:

1. CH2M HILL: Control System Integrator.
2. FDT: Factory Demonstration Test.
3. I&C: Instrumentation and Control.
4. I/O: Input and Output.
5. O&M: Operation and Maintenance.
6. P&ID: Process and Instrument Diagram.
7. PC: Personal Computer.
8. PIC: Process Instrumentation and Control.
9. PLC: Programmable Logic Controller.
10. SCADA: Supervisory Control and Data Acquisition.

1.05 SUBMITTALS

A. General:

1. In accordance with Section 01 33 00, Submittal Procedures.
2. Identify proposed items, options, installed spares, and other provisions for future work (for example, reserved panel space; unused components, wiring, and terminals).

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B. Action Submittals:

1. General: Manufacture of the control panels shall not commence until related submittals have been approved by CH2M HILL.
2. Submittal Requirements:
    a. Catalog Cuts and Product Information: For I&C components, electrical devices, and mechanical devices that are not supplied by CH2M HILL:
        1) Catalog information, marked to identify proposed items and options.
        2) Descriptive literature.
        3) External power and signal connections.
        4) Scaled drawings showing exterior dimensions and locations of electrical and mechanical interfaces.
    b. Layout Drawings:
        1) CH2M HILL will provide control panel layout drawings including the following information:
            a) Front, rear, and internal panel views to scale.
            b) Dimensional information.
            c) Tag number and functional name of components mounted in and on the panel.
            d) Product information on panel components provided by CH2M HILL.
            e) Nameplate location and legend including text, letter size and colors to be used.
            f) Location of external wiring and/or piping connections.
            g) Mounting and installation details.
            h) Calculations for heating and cooling.
            i) Subpanel layouts and mounting details for all items located inside control panels.
        2) Submit neat and legible mark ups of CH2M HILL drawings with the following information:
            a) Product information on all panel components not provided by CH2M HILL.
            b) Location of anchoring connections and holes.
    c. Wiring and/or Piping Diagrams:
        1) CH2M HILL will provide control panel wiring and/or piping diagrams including the following information:
            a) Name of panel, console or cabinet.
            b) Wiring sizes and types.
            c) Piping sizes and types.
            d) Terminal strip numbers.
            e) Color coding.
            f) For components supplied by CH2M HILL, functional name and manufacturer’s designation for components to which wiring and piping are connected.

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g) Wires: Wire number and color. Cable number if part of multiconductor cable.
h) Terminals: Location (enclosure number, terminal junction box number, or MCC number), terminal strip number, and terminal block number.
i) Components:
(1) Tag number, terminal numbers, and location ("FIELD," enclosure number, or MCC number).
(2) Switching action (open or close on rising or falling process variable), setpoint value and units, and process variable description (for example, Sump Level High).
j) I/O Points: PLC unit number, I/O tag number, I/O address, terminal numbers, and terminal strip numbers.
k) Relay Coils:
(1) Tag number and its function.
(2) On right side of run where coil is located, contact location by ladder number and sheet number. Underline normally closed contacts.
l) Relay Contacts: Coil tag number, function, and coil location (ladder rung number and sheet number).
m) Communications and Networks: Network type, address or node identification, port or channel number, and type of connector.
n) Ground wires, surge protectors, and connections.
o) Wire and Cable Names: Names, wire number, and wire color for circuits entering and leaving a panel.

2) Submit neat and legible mark ups of CH2M HILL control panel wiring and/or piping diagrams with the following information:
a) For components not supplied by CH2M HILL, functional name and manufacturer's designation for components to which wiring and piping are connected.
b) Revisions needed to correct incomplete or incorrect information.

d. Bill of Materials:
1) CH2M HILL will provide a Bill of Materials for each panel including tag number, functional name, manufacturer's name, model number and quantity for all components provided by CH2M HILL mounted in or on the panel or enclosure.
2) Submit Bill of Materials for components not provided by CH2M HILL.

e. Submit electronic copies of drawings markups in pdf format.

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C. Informational Submittals:

1. Manufacturer's O&M manuals for components, electrical devices, and mechanical devices that are not provided by CH2M HILL:
   a. In accordance with Section 01 78 23, Operation and Maintenance Data.
   b. Content for Each O&M Manual:
      1) Table of Contents.
      2) Operations procedures.
      3) Installation requirements and procedures.
      4) Maintenance requirements and procedures.
      5) Troubleshooting procedures.
      6) Calibration procedures.
      7) Internal schematic and wiring diagrams.
2. Testing Related Submittals:
   a. Factory Demonstration Test:
      1) Proposed test procedures, forms, and checklists.
      2) Test Documentation: Copy of signed off test results.
3. Record Drawings and Documentation:
   a. Submit final markups of CH2M HILL panel drawings, wiring diagrams, and documentation to reflect any updates made to the panels during fabrication and testing.
   b. Provide electronic copies of the markups in Adobe Acrobat pdf format.
4. Submit anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.

1.06 QUALITY ASSURANCE

A. General: The Supplier shall supply its company's Quality Assurance Plan. The plans shall include but not necessarily be limited to method of testing, raw material criteria, methods of documentation, station control, "Burn-In," final tests and serialization coding and packaging.

B. Qualifications:

1. Financially sound with minimum of 5 years' experience in designing and manufacturing similar control panels as required for this Project.
2. Have a UL approved panel shop.
3. Have a record of prompt shipments in accordance with contract obligations required for previous projects.

1.07 DELIVERY, STORAGE, AND HANDLING

A. In accordance with Section 01 61 00, Common Product Requirements.

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B. Packaged at the factory prior to shipment to protect each item from damage during shipment and storage. Containers protected against impact, abrasion, corrosion, discoloration and/or other damages. Clearly label contents of each container and provide information on the required storage conditions necessary for the equipment.

C. Notify CH2M HILL of the storage requirements and recommendations for the equipment prior to shipment.

D. Prior to shipment, include corrosive inhibitive vapor capsules in shipping containers, and related equipment as recommended by capsule manufacturer.

1.08 SEQUENCING AND SCHEDULING

A. Prerequisite Activities and Lead Times: Do not start following key Project activities until prerequisite activities and lead times listed below have been completed and satisfied:

1. Test Prerequisite: Associated test procedures Submittals completed.
2. Factory Demonstration Test Prerequisite:
   a. Approval of Control Panel submittals.
   b. Test procedures submittals completed.
3. Control Panels Shipment to Site:
   a. Prerequisites:
      1) Approval of Shop Drawings.
      2) Factory Demonstration Test (FDT) completed.

PART 2 PRODUCTS

2.01 GENERAL

A. Provide control panels listed in the Control Panel Schedule in Article Supplement at end of this Section, and in accordance with the control panel layout drawings and wiring diagrams provided by CH2M HILL.

B. Like Equipment Items: Use products of one manufacturer and of the same series or family of models to achieve standardization for appearance, operation, maintenance, spare parts, and manufacturer’s services.

C. Reference Control Panel Schedule in Section 40 92 01, Control Panels, for listing of Control Panels provided under this Section.

D. Reference Contract Drawings and Section 40 92 05, Programmable Logic Controllers, and Supplements PLC Equipment List and PLC Input Output IO List for additional requirements supporting the assembly of panels provided under this Section.

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E. Reference Contract Drawings and Section 40 92 06, Network and Computer Components, for listing of network hardware requirements supporting the assembly of panels provided under this Section.

F. Reference Contract Drawings and Section 40 95 80, Fiber Optic Communication System, for listing of fiber cable and hardware requirements supporting the assembly of panels provided under this Section.

2.02 CONTROL PANEL COMPONENTS

A. Provide all components and hardware not provided by CH2M HILL necessary to make each control panel fully operational and in conformance with requirements specified in this Section.

2.03 SERVICE CONDITIONS

A. Service Conditions for Panels: As noted in Control Panel Schedule located in Article Supplement at end of this Section. Design panels for continuous operation in these environments:

1. Freestanding Panel and Consoles:
   a. Inside: NEMA 12, unless otherwise Noted.
   b. Outside: NEMA 4X.
2. Smaller Panels and Assemblies (that are not freestanding):
   a. Inside, Air Conditioned: NEMA 12, unless otherwise Noted.
   b. All Other Non-Hazardous Locations: NEMA 4X.
   c. Hazardous Locations: NEMA 7.

2.04 NAMEPLATES AND TAGS

A. Panel Nameplates: For identification of panels and components mounted thereon.

1. Nameplate Size and Material: 3/32-inch thick laminated phenolic type with black matte finish surface and white letter engraving.
2. Panel Identification Nameplates: 1/2-inch high letter engravings.
3. Panel Mounted Component (e.g., Control Devices, Indicating Lights, Selector Switches, etc.) Identification Nameplates: 1/4-inch high letter engravings.
4. Attached to the panel face with two stainless steel self-tapping screws.
5. Nameplate Engravings: Include the instrument or equipment tag number and descriptive title as shown and specified.

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B. Internally Mounted Instruments Tags:

1. Tag Numbers: As listed in the Contract Documents.
2. Identifying Tag Number: Permanently etched or embossed onto a stainless steel tag which shall be fastened to the device housing with stainless steel rivets or self-tapping screws of appropriate size.
3. Where neither of the above fastenings can be accomplished, tags shall be permanently attached to the device by a circlet of 1/16-inch diameter stainless steel wire rope.
4. Identification Tag: Installed so that the numbers are easily visible to service personnel.
5. Front of Panel Mounted Instruments: Tag attached to rear of device.

C. Tagging of the following items shall be accomplished with the use of adhesive plastic Brady USA, Inc. labels, or equal.

1. Tag all electrical devices (e.g., relays, timers, power supplies) mounted within control panels and enclosures.
2. Tag all pneumatic lines.
3. Numerically tag all terminal blocks.
4. Numerically tag wiring at each end.

D. Legend Plates for Panel Mounted Pushbuttons, Lights, and Switches.

1. Inscription:
   a. Refer to table under Paragraph Standard Pushbutton Colors and Inscriptions.
   b. Refer to table under Paragraph Standard Light Colors and Inscriptions.
   c. Refer to P&IDs and panel drawings.
2. Materials: Stainless steel, keyed legend plates. Secured to panel by mounting nut for pushbutton, light, or switch.
3. Letters: Black on gray or white background.

E. Service Legends: Component identification nameplate located on face of component.

1. Inscription: As shown on panel drawings.
2. Materials: Adhesive-backed, laminated plastic.
3. Letters: 3/16-inch-high, white on black background, unless otherwise noted.

F. Nametags: Component identification for field devices.

1. Inscription: Component tag number.
2. Materials: 16-gauge, Type 304 stainless steel.
3. Letters: 3/16-inch-high, imposed.

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4. Mounting: Affix to component with 16-gauge or 18-gauge stainless steel wire rope or stainless steel screws.

2.05 MECHANICAL SYSTEM COMPONENTS

A. Manifold, Two-Valve Block and Bleed:

1. Type: For isolation, calibration, and venting of pressure instruments.
2. Materials: Stainless steel.
3. Manufacturer and Product:
   a. Anderson Greenwood; Type M25.
   b. Or equal.

B. Manifold, Three-Valve Equalizing:

1. Type: For isolation and equalization of differential pressure transducers.
2. Materials: Stainless steel.
3. Manufacturers and Products:
   a. Anderson, Greenwood and Co.; Type M1.
   b. Evans.

C. Pressure Gauge: For other than process variable measurement.

1. Dial Size: Nominal 2-inch dial size.
2. Accuracy: 2 percent of span.
3. Scale Range: Such that normal operating pressure lies between 50 percent and 80 percent of scale range.
4. Connection: 1/4-inch NPT through bottom, unless otherwise noted.
5. Manufacturers and Products:
   a. Ashcroft Utility; Gauge Series 1000.
   b. Marsh; Standard Gauge Series.
   c. Ametek U.S.; Gauge Series P500.
   d. Acculite; Series 2000.

D. Valve, Needle:

1. Materials: Brass, stainless steel, PVC, or CPCV, as recommended by manufacturer for designated service, unless otherwise shown on Drawings.
2. Size: 0.020-inch orifice.
3. Manufacturers and Products:
   a. Whitey; Model 21RF2.
   b. Hoke; 3700 Series.

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E. ON/OFF Valves:

1. Type: Ball valve.
2. Materials: Brass, stainless steel, PVC, or CPCV, as recommended by manufacturer for designated service, unless otherwise shown on Drawings.
3. Manufacturers and Products:
    a. Whitey; Series 41 through Series 43.
    b. Hoke; Flomite 7100 Series.

F. Test Tap:

1. Manufacturers and Products:
    a. Imperial-Eastman; quick-disconnect couplings No. 292-P and caps No. 259-P.
    b. Crawford Fitting Co.; Swagelok quick-connects Series QC4 and caps QC4-DC.
    c. Parker; CPI Series precision quick couplings.

G. Copper Tubing and Fittings:

1. Type K hard copper, ASTM B88, with commercially pure wrought copper solder joint fittings. Make joints with 95-5 wire solder, ASTM B32, Grade 95 TA. Do not use cored solder.
2. Alternatively, Type K, soft temper copper tubing, ASTM B88, with brass compression type fittings may be used where shown on Drawings.
3. Manufacturers:
    a. Swagelok tube fittings.
    b. Parker-Hannifin.

H. Plastic Tubing and Fittings:

1. Tubing:
    a. Polyethylene capable of withstanding 190 psig at 175 degrees F.
    b. Manufacturers and Products:
        1) Dekoron; Type P.
        2) Imperial Eastman; Poly-Flo black instrument tubing.
2. Fittings:
    a. Type: Brass compression.
    b. Manufacturers and Products:
        1) Imperial Eastman; Poly-Flo tube fittings.
        2) Dekoron; E-Z fittings.

I. Stainless Steel Tubing: ASTM A312/A312M, Type 316, 0.065-inch wall, seamless, soft annealed, as shown on Drawings.

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J. Stainless Steel Fittings:

1. Compression Type:
   a. Materials: Type 316 stainless steel, ASTM A182/A182M forged bodies or ASTM A276 barstock bodies, flareless.
   b. Manufacturers and Products:
      1) Swagelok tube fittings.
      2) Parker Flodar; BA Series.
      3) Parker CPI tube fittings; Parker A-LOK dual ferrule tube fittings.
2. Socket Weld Type:
   a. Materials: Type 316 stainless steel, ASTM A182/A182M forged bodies or ASTM A276 barstock bodies, 3,000 psi maximum working pressure, safety factor 4:1.
   b. Manufacturers:
      1) Cajon.
      2) Swagelok.
      3) Parker WELDLOK.

K. Air Set: Consists of a shutoff valve, pressure regulator, discharge pressure gauge, and interconnecting tubing.

L. Tubing Raceways:

1. Cable tray systems complete with tees, elbows, reducers, and covers.
2. Size in accordance with manufacturer’s recommendations for intended service.
3. Materials: Galvanized steel or aluminum brass as recommended by manufacturer for designated service, unless otherwise shown on Drawings.
4. Manufacturers:
   a. Globetray.
   b. Cope.

2.06 ELECTRICAL REQUIREMENTS

A. I&C and electrical components, terminals, wires, and enclosures UL recognized or UL listed.

B. Wires Within Enclosures:

1. ac Circuits:
   a. Type: 600-volt, Type MTW stranded copper.
   b. Size: For current to be carried, but not less than No. 18 AWG.

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2. Analog Signal Circuits:
    a. Type: 600-volt stranded copper, twisted shielded pairs or triad with a 100 percent, aluminum-polyester shield, rated 60 degrees C.
    b. Panels with Circuits Less Than 600 volts: Rated at 600 volts. Belden No. 18 AWG Type 9341, Triad Beldon No. 1121A.
    c. Size: No. 18 AWG, minimum.
3. Other dc Circuits:
    a. Type: 600-volt, Type MTW stranded copper.
    b. Size: For current carried, but not less than No. 18 AWG.
4. Special Signal Circuits: Use manufacturer's standard cables.
5. Separate analog and other dc circuits by at least 6 inches from ac power and control wiring, except at unavoidable crossover points and at device terminations.
6. Color code and separate intrinsic safety circuits from non-intrinsic safety circuits by at least 2 inches in accordance with NEC Article 504 and UL 508 requirements. Provide separate conduits for instrinsic safety per NEC Article 504.
7. Wire Identification: Numbered and tagged at each termination.
    a. Wire Tags: Machine printed, heat shrink.
    b. Manufacturers:
        1) Brady Perma Sleev.
        2) Tyco Electronics.

C. Terminal Blocks for Enclosures:

1. Quantity:
    a. Accommodate present and 20 percent spare indicated needs.
    b. All spare IO wired to field terminal blocks for future use.
    c. One wire per terminal for field wires entering enclosures.
    d. Maximum of two wires per terminal for No. 18 AWG wire for internal enclosure wiring.

D. Multiple Process Trains: Wire field devices for multiple process trains to alternate PLC Input-Output (IO) modules such that one module does not drop out multiple process trains.

E. Grounding of Enclosures:

1. Furnish isolated copper grounding bus for signal and shield ground connections.
2. Ground this ground bus at a common signal ground point in accordance with National Electrical Code requirements.
3. Single Point Ground for Each Analog Loop:
    a. Locate signal ground at dc power supply for loop.
    b. Use to ground wire shields for loop.

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c. Group and ground wire shields in PLC control panels or PLC remote I/O panels.

4. Ground terminal block rails to ground bus.

2.07 PANEL FABRICATION

A. General:

1. Nominal Panel Dimensions: Refer to control panel layout drawings.
2. Panel Construction and Interior Wiring: In accordance with the National Electrical Code (NEC), state and local codes, and applicable sections of NEMA, ANSI, UL, and ICECA.
3. Fabricate panels, install instruments and wire, and plumb at panel Supplier's facility. No fabrication other than correction of minor defects or minor transit damage permitted onsite.
4. UL Listing Mark for Enclosures: Mark stating "Listed Enclosed Industrial Control Panel" per UL 508A.
5. Electrical Work: In accordance with the applicable requirements of Division 26, Electrical.

B. Temperature Control:

1. Freestanding Panels:
   a. Nonventilated Panels: Size to adequately dissipate heat from equipment mounted inside panel and on panel.
   b. Ventilated Panels:
      1) Furnish with louvers and forced ventilation as required to prevent temperature buildup from equipment mounted inside panel and on panel.
      2) For panels with backs against wall, furnish louvers on top and bottom of panel sides.
      3) For panels without backs against wall, furnish louvers on top and bottom of panel back.
      4) Louver Construction: Stamped sheet metal.
      5) Ventilation Fans:
         a) Furnish where required to provide adequate cooling.
         b) Create positive internal pressure within panel.
         c) Fan Motor Power: 120V ac, 60-Hz, thermostatically controlled.
      6) Air Filters: Washable aluminum, Hoffman Series A-FLT.
2. Smaller Panels (that are not freestanding): Size to adequately dissipate heat from equipment mounted inside panel and on panel face.
3. Space Heaters:
   a. Thermostatically controlled to maintain internal panel temperatures above dewpoint.
   b. Refer to Control Panel Schedule in Article Supplement.

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4. Enclosures installed outdoors or indoors in spaces that are not conditioned:
    a. For enclosures with programmable logic controllers, microprocessors, or when noted:
        1) Provide NEMA 4/4X side-mounted or top-mounted closed-loop air conditioning unit. Size the unit to maintain temperatures inside the enclosure to no more than 45 degrees C with an ambient temperature of 50 degrees C in full sun and the equipment operating at full load or highest rating of most sensitive equipment. Provide heat loading and cooling calculations.
        2) Air Conditioner Power: 120 volts, provided by an external circuit, for loads exceeding 15A.
        3) See Control Panel Schedule in Article Supplement.
    b. For Other Enclosures: Furnish thermostatically controlled fans with replaceable air filters to dissipate heat generated in the panel and heaters to maintain temperature above 40 degrees F. Provide thermostats to automatically control heating and cooling requirements to maintain the temperature inside the enclosure within the ratings of the components inside the enclosure.

C. Freestanding Panel Construction:

1. Materials:
    a. Indoor Installation: Sheet steel, unless otherwise shown on Drawings.
    b. Outdoor Installations: Type 316 stainless steel.
    c. Minimum Thickness: 12-gauge, unless otherwise noted.
2. Panel Rating:
    a. Indoor: NEMA 12 unless otherwise noted.
    b. Non-Hazardous Outdoor: NEMA 4X.
3. Panel Front:
    a. Fabricated from a single piece of sheet steel, unless otherwise shown on Drawings.
    b. No seams or bolt heads visible when viewed from front.
    c. Panel Cutouts: Smoothly finished with rounded edges.
    d. Stiffeners: Steel angle or plate stiffeners or both on back of panel face to prevent panel deflection under instrument loading or operation.
4. Internal Framework:
    a. Structural steel for instrument support and panel bracing.
    b. Permit panel lifting without racking or distortion.
5. Sub-panels for installation of relays and other internally mounted components.
6. Lifting rings to allow simple, safe rigging and lifting of panel during installation.

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7. Adjacent Panels: Securely bolted together so front faces are parallel.
8. Door:
    a. Full height, fully gasketed access door where shown on Drawings.
    b. Latch: Three-point.
    c. Handle: “D” ring, foldable type.
    d. Hinges: Full-length, continuous, piano-type, steel hinges with stainless steel pins.
    e. Rear Access: Extend no further than 24 inches beyond panel when opened to 90-degree position.
    f. Front and Side Access Doors: As shown on Drawings.
9. Bottom 12 Inches: Free of all devices, including terminal strips, to provide ease of installation and testing.

D. Nonfreestanding Panel Construction:

1. Provide the following unless otherwise noted in Control Panel Schedule in Article Supplement:
    a. Panels listed as inside:
        1) Enclosure Type: NEMA 12, unless otherwise noted.
        2) Materials: Steel.
    b. Other Panels:
        1) Enclosure Type: NEMA 4X (non-hazardous).
        2) Materials: Type 316 stainless steel.
    c. Other Panels:
        1) Enclosure Type: NEMA 4X (non-hazardous).
        2) Materials: Type 316 stainless steel.
    d. Hazardous Locations:
        1) Enclosure Type: NEMA 7.
        2) Materials: Cast aluminum.
2. Doors:
    a. Rubber-gasketed with continuous hinge.
    b. Stainless steel lockable quick-release clamps.
    c. Hinged and bolted (Hazardous locations).
3. Manufacturers:
    a. Saginaw Control Engineering (SCE).
    b. Hoffman Engineering Co.
    c. Appleton.
    d. Cooper Industries, Crouse-Hinds.

E. Breather and Drains: Furnish with NEMA 250, Type 4 and 4X panels:

1. Manufacturer and Product: Cooper Crouse-Hinds; ECD Type 4X Drain and Breather; Drain Model ECD1-N4D, Breather Model ECD1-N4B.

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F. Control Panel Electrical:

1. Power Distribution within Panels:
    a. Feeder Circuits:
        1) One or more 120V ac, 60-Hz feeder circuits as shown on Drawings. Control panels will be provided with one non-UPS circuit except as follows:
            a) PLC Panels one circuit (Non-UPS with internal UPS).
            b) Analytical Instrument Panels two or three circuits as shown (UPS and Non-UPS and HVAC Power).
            c) Network Interface Panels multiple circuits (UPS and Non-UPS Power).
        2) UPS power circuits provided under this section based upon panel demand loads. UPS sizes preliminary based upon anticipated loading. Final demand loading to be determines as part of Panel design and assembly.
        3) Make provisions for feeder circuit conduit entry.
        4) Furnish terminal block for termination of wires.
    b. Power Panel: Furnish main circuit breaker and circuit breaker on each individual branch circuit distributed from power panel.
        1) Locate to provide clear view of and access to breakers when door is open.
        2) Branch Circuit Breaker Sizes: Coordinate such that fault in branch circuit will trip only the branch breaker, but not trip the main breaker.
            a) Branch Circuit Breakers: 15 amps and 20 amps at 250V ac.
        3) Sub-branch Circuit Breakers:
            a) Provide as required to distribute power to PLC I/O circuits and 120V ac field instruments.
            b) Size circuit breakers as required to protect each sub-branch circuit without tripping the associated branch circuit.
        4) Breaker Manufacturers and Products: Refer to Division 26, Electrical.
    c. Circuit Wiring: P&IDs and Control Diagrams on Drawings show function only. Use following rules for actual circuit wiring:
        1) Devices on Single Circuit: 20, maximum.
        2) Multiple Units Performing Parallel Operations: To prevent failure of any single branch circuit from shutting down entire operation, do not group all units on same branch circuit.
        3) Branch Circuit Loading: 12 amperes continuous, maximum.
        4) Panel Lighting and Service Outlets: Put on separate 15 amp, 120V ac branch circuit.

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5) Provide 120V ac plugmold for panel components with line cords.

2. Signal Distribution:
   a. Signal Wiring: Separate analog signal cables from power and control within a panel and cross at right angles where necessary.
   b. Within Panels: 4 to 20 mA dc signals may be distributed as 1V dc to 5V dc.
   c. Outside Panels: Isolated 4 to 20 mA dc only.
   d. Signal Wiring: Twisted shielded pairs.
   e. RTD and Thermocouple Extension Cable:
      1) Continuous field to panel with no intermediate junction boxes or terminations.
      2) RTDs in motor windings are considered a 600-volt circuit.
      3) Terminate thermocouple extension wire directly to loop instrument.
3. Signal Switching:
   a. Use dry circuit type relays or switches.
   b. No interruption of 4 to 20 mA loops during switching.
   c. Switching Transients in Associated Signal Circuit:
      1) 4 to 20 mA dc Signals: 0.2 mA, maximum.
      2) 1V dc to 5V dc Signals: 0.05V, maximum.
4. Push-to-Test Circuitry: For each push-to-test indicating light, provide a fused push-to-test circuit.
5. Internal Panel Lights and Switch for Freestanding Panels:
   a. Type: Switched LED.
   b. Quantity: One light for every 4 feet of panel width.
   c. Mounting: Inside and in the top of back-of-panel area.
   d. Protective metal shield for lights.
   e. Light Switch: Door operated.
6. Service Outlets for Freestanding Panels:
   a. Type: Three-wire, 120-volt, 20-ampere, GFCI duplex receptacles.
   b. Quantity:
      1) Panels 4 Feet Wide and Smaller: One.
      2) Panels Larger than 4 Feet Wide: One for every 4 feet of panel width, two minimum per panel.
7. Internal Panel Lights and Service Outlets for Smaller Panels:
   a. Internal Panel Light and Switch: Switched LED type with door operated light switch.
   b. Service Outlet: Breaker protected 120-volt, 20-amp, GFCI duplex receptacle:
   c. Required for panels. Refer to Control Panel Schedule in Article Supplement and panel concept drawings.

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8. Standard Pushbutton Colors and Inscriptions:
   a. Use following unless otherwise noted in Instrument List:

Tag Function	Inscription(s)	Color
OO	ON OFF	Black Black
OC	OPEN CLOSE	Black Black
OCA	OPEN CLOSE AUTO	Black Black Black
OOA	ON OFF AUTO	Black Black Black
MA	MANUAL AUTO	Black Black
SS	START STOP	Black Black
LC	LOCAL COMPUTER	Black Black
RESET	RESET	Black
EMERGENCY STOP	EMERGENCY STOP	Red

   b. Lettering Color:
      1) Black on white and yellow buttons.
      2) White on black, red, and green buttons.
9. Standard Light Colors and Inscriptions:
   a. Use following color code and inscriptions for service legends and lens colors for indicating lights, unless otherwise noted in Instrument List:

Tag Function	Inscription(s)	Color
ON or RUNNING	ON or RUNNING	Red
OFF	OFF	Green
BREAKER OPEN	BREAKER OPEN	Green
VALVE OPEN	VALVE OPEN	Red
VALVE CLOSED	VALVE CLOSED	Green

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Tag Function	Inscription(s)	Color
BREAKER CLOSED	BREAKER CLOSED	Red
LOW	LOW	Amber
FAIL	FAIL	Amber
HIGH	HIGH	Amber
AUTO	AUTO	White
MANUAL	MANUAL	Yellow
LOCAL	LOCAL	White
REMOTE	REMOTE	Yellow
GAS DETECTED	GAS DETECTED	Blue
REVERSE	REVERSE	Blue
FORWARD	FORWARD	Red

b. Lettering Color:
   1) Black on white and amber lenses.
   2) White on red and green lenses.

G. Electrical Components:

1. Terminal Blocks for Enclosures:
   a. General:
      1) Connection Type: Screw compression clamp.
      2) Compression Clamp:
         a) Complies with DIN-VDE 0611.
         b) Hardened steel clamp with transversal grooves that penetrate wire strands providing a vibration-proof connection.
         c) Guides strands of wire into terminal.
      3) Screws: Hardened steel, captive, and self-locking.
      4) Current Bar: Copper or treated brass.
      5) Insulation:
         a) Thermoplastic rated for minus 55 degrees C to plus 110 degrees C.
         b) Two funneled shaped inputs to facilitate wire entry.
      6) Mounting:
         a) Standard DIN rail.
         b) Terminal block can be extracted from an assembly without displacing adjacent blocks.
         c) End Stops: Minimum of one at each end of rail.

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7) Wire Preparation: Stripping only permitted.
8) Jumpers: Allow jumper installation without loss of space on terminal or rail.
9) Marking System:
    a) Terminal number shown on both sides of terminal block.
    b) Allow use of preprinted and field marked tags.
    c) Terminal strip numbers shown on end stops.
    d) Mark terminal block and terminal strip numbers as shown on panel control diagrams and loop diagrams.
    e) Fuse Marking for Fused Terminal Blocks: Fuse voltage and amperage rating shown on top of terminal block.

b. Terminal Block, General Purpose:
1) Rated Voltage: 600V ac.
2) Rated Current: 30-amp.
3) Wire Size: 24 AWG to 10 AWG.
4) Rated Wire Size: 10 AWG.
5) Color: Gray body.
6) Spacing: 1/4-inch, maximum.
7) Manufacturers:
    a) Weidmuller.
    b) Entrelec.
    c) Or equal.

c. Terminal Block, Ground:
1) Wire Size: 24 AWG to 10 AWG.
2) Rated Wire Size: 10 AWG.
3) Color: Green and yellow body.
4) Spacing: 1/4-inch, maximum.
5) Grounding: Electrically grounded to mounting rail.
6) Manufacturers:
    a) Weidmuller.
    b) Entrelec.
    c) Or equal.

d. Terminal Block, Blade Disconnect Switch:
1) Rated Voltage: 600V ac.
2) Rated Current: 10-amp.
3) Wire Size: 22 AWG to 10 AWG.
4) Rated Wire Size: 10 AWG.
5) Color: Gray body, orange switch.
6) Spacing: 1/4-inch, maximum.
7) Manufacturers:
    a) Weidmuller.
    b) Entrelec.
    c) Or equal.

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e. Terminal Block Diode:
    1) Rated Voltage: 24V dc.
    2) Rated Current: 30 mA.
    3) Wire Size: 16 AWG.
    4) Manufacturer:
        a) Phoenix Contact.
        b) Or equal.

f. Terminal Block, Fused, 24V dc:
    1) Rated Voltage: 600V dc.
    2) Rated Current: 25-amp.
    3) Wire Size: 22 AWG to 10 AWG.
    4) Rated Wire Size: 10 AWG.
    5) Color: Gray body.
    6) Fuse: 1/4-inch by 1-1/4 inches.
    7) Indication: LED diode 24V dc.
    8) Spacing: 0.512-inch, maximum.
    9) Manufacturers:
        a) Schneider Electric/Square D.
        b) Entrelec.
        c) Or equal.

g. Terminal Block, Fused, 120V ac:
    1) Rated Voltage: 600V ac.
    2) Rated Current: 25-amp.
    3) Wire Size: 22 AWG to 10 AWG.
    4) Rated Wire Size: 10 AWG.
    5) Color: Gray body.
    6) Fuse: 1/4-inch by 1-1/4 inches.
    7) Indication: Neon lamp, 110V ac.
    8) Leakage Current: 1.8 mA, maximum.
    9) Spacing: 0.512-inch, maximum.
    10) Manufacturers:
        a) Schneider Electric/Square D.
        b) Entrelec.
        c) Or equal.

h. Terminal Block, Fused, 120V ac, High Current:
    1) Rated Voltage: 600V ac.
    2) Rated Current: 35-amp.
    3) Wire Size: 18 AWG to 8 AWG.
    4) Rated Wire Size: 8 AWG.
    5) Color: Gray.
    6) Fuse: 13/32-inch by 1-1/2 inches.
    7) Spacing: 0.95-inch, maximum.
    8) Manufacturers:
        a) Schneider Electric/Square D.
        b) Entrelec.
        c) Or equal.

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2. Relays:
    a. General:
        1) Relay Mounting: Double-pole contacts minimum plug-in type socket. Terminal block style relays are acceptable.
        2) Relay Enclosure: Furnish dust cover.
        3) Socket Type: Screw terminal interface with wiring.
        4) Socket Mounting: Rail.
        5) Provide holddown clips.
    b. Signal Switching Relay:
        1) Type: Dry circuit.
        2) Contact Arrangement: DPDT or 3 Form C contacts.
        3) Contact Rating: 5 amps at 28V dc or 120V ac.
        4) Contact Material: Gold or silver.
        5) Coil Voltage: As noted or shown.
        6) Coil Power: 0.9 watt (dc), 1.2VA (ac).
        7) Expected Mechanical Life: 10,000,000 operations.
        8) Expected Electrical Life at Rated Load: 100,000 operations.
        9) Indication Type: Neon or LED indicator lamp.
        10) Seal Type: Hermetically sealed case.
        11) Manufacturer and Product: Potter and Brumfield; Series KH/KHA.
    c. Control Circuit Switching Relay, Nonlatching:
        1) Type: Compact general purpose plug-in.
        2) Contact Arrangement: DPDT or 3 Form C contacts.
        3) Contact Rating: 10A at 28V dc or 120V ac, and 6.6A at 240V ac.
        4) Contact Material: Silver cadmium oxide alloy.
        5) Coil Voltage: As noted or shown.
        6) Coil Power: 1.8 watts (dc), 2.7VA (ac).
        7) Expected Mechanical Life: 10,000,000 operations.
        8) Expected Electrical Life at Rated Load: 100,000 operations.
        9) Indication Type: Neon or LED indicator lamp.
        10) Push-to-test button.
        11) Manufacturers and Products:
            a) Allen-Bradley; Bulletin 700-H.
            b) Potter and Brumfield; Series KUP.
            c) Or equal.
    d. Control Circuit Switching Relay, Latching:
        1) Type: Dual coil mechanical latching relay.
        2) Contact Arrangement: DPDT or 3 Form C contacts.
        3) Contact Rating: 10A at 28V dc or 120V ac.
        4) Contact Material: Silver cadmium oxide alloy.
        5) Coil Voltage: As noted or shown.
        6) Coil Power: 2.7 watts (dc), 5.3VA (ac).
        7) Expected Mechanical Life: 500,000 operations.
        8) Expected Electrical Life at Rated Load: 50,000 operations.

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9) Manufacturer and Product: Potter and Brumfield; Series KB/KBP.

e. Control Circuit Switching Relay, Time Delay:
1) Type: Adjustable time delay relay.
2) Contact Arrangement: DPDT or 3 Form C contacts.
3) Contact Rating: 10A at 30V dc or 277V ac.
4) Contact Material: Silver cadmium oxide alloy.
5) Coil Voltage: As noted or shown.
6) Operating Temperature: Minus 10 degrees C to 55 degrees C.
7) Repeatability: Plus or minus 2 percent.
8) Delay Time Range: Select range such that time delay setpoint fall between 20 to 80 percent of range.
9) Time Delay Setpoint: As noted or shown.
10) Mode of Operation: As noted or shown.
11) Adjustment Type: Integral potentiometer with knob external to dust cover.
12) Manufacturer and Products: Potter and Brumfield; Series CB for 0.1-second to 100-minute delay time ranges, Series CK for 0.1-second to 120-second delay time ranges.

H. Front-of-Panel Devices Used in Conjunction with NEMA 250, Type 4X Panels:

1. Potentiometer, Watertight:
a. Three-terminal, heavy-duty NEMA 250, Type 4X watertight construction, resolution of 1 percent and linearity of plus or minus 5 percent.
b. Single-hole, panel mounting accommodating panel thicknesses between 1/8 and 1/4 inch or 30.5 mm as required.
c. Include engraved legend plates with service markings.
d. Manufacturer and Product:
1) Allen-Bradley; Bulletin 800H.
2) Or equal.
2. Indicating Lights, Watertight:
a. Heavy-duty, push-to-test type, NEMA 250, Type 4X watertight, industrial type with integral transformer for 120V ac applications and corrosion-resistant service.
b. Single-hole, panel mounting accommodating panel thicknesses between 1/8 and 1/4 inch or 30.5 mm as required.
c. Screwed on prismatic lenses and factory engraved legend plates for service legend.

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d. Manufacturers and Products:
    1) Square D; Type SK.
    2) Allen-Bradley; Type 800H.
    3) Or equal.

3. Pushbutton, Momentary, Watertight:
    a. Heavy-duty, NEMA 250, Type 4X watertight, industrial type with momentary contacts rated for 120V ac service at 10 amperes continuous and corrosion-resistant service.
    b. Single-hole, panel mounting accommodating panel thicknesses between 1/8 and 1/4 inch or 30.5 mm as required.
    c. Standard size, black field, legend plates with white markings for service legend.
    d. Manufacturers and Products:
        1) Square D; Type SK.
        2) Allen-Bradley; Type 800H.
        3) Or equal.
4. Selector Switch, Watertight:
    a. Heavy-duty, NEMA 250, Type 4X watertight, industrial type with contacts rated for 120V ac service at 10 amperes continuous and corrosion-resistant service.
    b. Standard size, black field, legend plates with white markings, for service legend.
    c. Operators: Black knob type.
    d. Single-hole mounting, accommodating panel thicknesses from 1/16 to 1/4 inch or 30.5 mm as required.
    e. Manufacturer and Products:
        1) Square D; Class 9001, Type SK.
        2) Allen-Bradley; Type 800H.
        3) Or equal.

I. Front-of-Panel Devices Used in Conjunction with NEMA 250, Type 7 Panels:

1. Pushbutton, Momentary, Watertight:
    a. Heavy-duty, NEMA 250, Type 7 industrial and hermetically sealed type with momentary contacts rated for 120V ac service at 10 amperes continuous and corrosion-resistant service.
    b. Single-hole, panel mounting accommodating panel thicknesses between 1/8- and 1/4-inch or 30.5 mm as required.
    c. Standard size, black field, legend plates with white markings for service legend.
    d. Manufacturers and Products:
        1) Square D; Type SK.
        2) Allen-Bradley; Type 800H.
        3) Or equal.

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2. Selector Switch, Watertight:
    a. Heavy-duty, NEMA 250, Type 4X watertight, industrial type with contacts rated for 120V ac service at 10 amperes continuous and corrosion-resistant service.
    b. Single-hole, panel mounting accommodating panel thicknesses between 1/8- and 1/4-inch or 30.5 mm as required.
    c. Standard size, black field, legend plates with white markings, for service legend.
    d. Operators: Black knob type.
    e. Single-hole mounting, accommodating panel thicknesses from 1/16 to 1/4 inch.
    f. Manufacturer and Products:
        1) Square D; Class 9001, Type BR or Hermetically sealed Type SK or KX.
        2) Allen-Bradley; Type 800H, 800G, 800R.
        3) Or equal.

J. Power Supplies:

1. Furnish dual power supplier as required to power instruments requiring external dc power, including two-wire transmitters and dc relays.
2. Provide dual power supplies with diode auctioneered outputs.
3. Convert 120V ac, 60-Hz power to dc power of appropriate voltage(s) with sufficient voltage regulation and ripple control to assure that instruments being supplied can operate within their required tolerances.
4. Provide output over voltage and over current protective devices to:
    a. Protect instruments from damage due to power supply failure.
    b. Protect power supply from damage due to external failure.
5. Enclosures: NEMA 1.
6. Mount such that dissipated heat does not adversely affect other components.
7. Fuses: For each dc supply line to each individual two-wire transmitter.
    a. Type: Indicating.
    b. Mount so fuses can be easily seen and replaced.
8. Manufacturer and Product:
    a. Phoenix Contact; Quint Series.
    b. Rockwell; Bulletin 1606 Series.
    c. Sola; Son Series.

K. Intrinsic Safety Barriers:

1. Intrinsically Safe Relays: Monitor discrete signals that originate in hazardous area and are used in a safe area.
    a. For additional requirements, reference National Electrical Code (NEC) Article 504 Intrinsically Safety Systems and NFPA 820

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Standard for Fire Protection in Wastewater Treatment and Collection Facilities; Table 5 and Table 6.

b. Manufacturer and Product:
   1) MTL, Inc.; Series MTL 5000.
   2) Or equal.

2. Intrinsically Safe Barriers: Interface analog signals as they pass from hazardous area to safe area.
   a. For additional requirements, reference National Electrical Code (NEC) Article 504 Intrinsically Safety Systems and NFPA 820 Standard for Fire Protection in Wastewater Treatment Collection Facilities; Table 5 and Table 6.
   b. Manufacturer and Product: MTL, Inc.:
      1) Series MTL 5000.
      2) Or equal.

L. Network Cable Category 6:

1. Type 30, Unshielded Twisted Pair (UTP) Telephone and Data Cable, 300V.
2. Category 6 UTP, UL listed, and third party verified to comply with TIA/EIA 568-B.2-1 Category 6 requirements.
3. Provide four each individually twisted pair, 23 AWG conductors.
4. NFPA 70 Plenum (CMP) rated.
5. Manufacturer and Product:
   a. Belden; 7852A.
   b. Siemon; 9C6P4-E4-06.
   c. Or equal.

M. Control Panel Internal Wiring:

1. Restrain by plastic ties or ducts or metal raceways.
2. Hinge Wiring: Secure at each end so bending or twisting will be around longitudinal axis of wire. Protect bend area with sleeve.
3. Arrange wiring neatly, cut to proper length, and remove surplus wire.
4. Provide abrasion protection for wire bundles that pass through holes or across edges of sheet metal.
5. Connections to Screw Type Terminals:
   a. Locking-fork-tongue or ring-tongue lugs.
   b. Use manufacturer’s recommended tool with required sized anvil to make crimp lug terminations.
   c. Wires terminated in a crimp lug, maximum of one.
   d. Lugs installed on a screw terminal, maximum of two.
6. Connections to Compression Clamp Type Terminals:
   a. Strip, prepare, and install wires in accordance with terminal manufacturer’s recommendations.

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b. Wires installed in a compression screw and clamp, maximum of one for field wires entering enclosure, otherwise maximum of two.

7. Splicing and tapping of wires, allowed only at device terminals or terminal blocks.
8. Terminate 24V dc and analog signal circuits on separate terminal block from ac circuit terminal blocks.
9. Separate analog and other dc circuits by at least 6 inches from ac power and control wiring, except at unavoidable crossover points and at device terminations.
10. Color code and separate intrinsic safety circuits from non-intrinsic safety circuits by at least 2 inches in accordance with NEC Article 504 and UL 508 requirements.
11. Arrange wiring to allow access for testing, removal, and maintenance of circuits and components.
12. Plastic Wire Duct Fill: Do not exceed manufacturer's recommendations.
13. Conductors Carrying Foreign Voltages within a Panel:
    a. Route foreign voltage conductors into panel and land on a circuit blade disconnect type terminal block.
    b. Use wire with pink insulation to identify foreign voltage circuits within panel from terminal block on. Do not use wires with pink insulation for any other purpose.
14. Harness Wiring:
    a. 120V ac: No. 14 AWG, MTW.
    b. 24V dc: No. 16 AWG, MTW where individual conductors are used and Type TC shielded tray cable where shielded wire is used.
15. Panelwork:
    a. No exposed connections.
    b. Allow adjustments to equipment to be made without exposing these terminals.
    c. For power and control wiring operating above 80V ac or dc use covered channels or EMT raceways separate from low voltage signal circuits.
16. Plastic Wire Ducts Color:
    a. 120V ac: White.
    b. 24V dc: Gray.
    c. Communications Cables and Fiber Optic Jumpers: Orange.
17. Provide a communications plastic wire duct for communications cables and fiber optic cables between the communications devices in control panel and communications raceways. Design plastic wire duct design to take into account the minimum bending radius of the communications cable.
18. Make plastic wire ducts the same depth.
19. Provide a minimum of 1-1/2 inches between plastic wire ducts and terminal blocks.

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N. Control Relay Arrangement: Install control relays associated with specific loops in same panel section as corresponding terminal blocks or side panels. Provide 10 percent space for future relays. Locate spare space in same sections as spare terminal blocks.

O. Factory Finishing:

1. Furnish materials and equipment with manufacturer's standard finish system in accordance with Section 09 90 00, Painting and Coating.
2. Use specific color if indicated. Otherwise use manufacturer's standard finish color, or light gray if manufacturer has no standard color.
3. Stainless Steel and Aluminum: Not painted.
4. Nonmetallic Panels: Not painted.
5. Steel Panels:
    a. Sand panel and remove mill scale, rust, grease, and oil.
    b. Fill imperfections and sand smooth.
    c. Paint panel interior and exterior with one coat of epoxy coating metal primer, two finish coats of two-component type epoxy enamel.
    d. Sand surfaces lightly between coats.
    e. Dry Film Thickness: 3 mils, minimum.
    f. Color: Manufacturer's standard.

2.08 ELECTRICAL SURGE AND TRANSIENT PROTECTION

A. Equip control panels with surge-arresting devices to protect equipment from damage as a result of electrical transients induced in interconnecting lines from lightning discharges and nearby electrical devices.

1. Provide wiring, hardware, and protective devices meeting the Requirements of UL 1449 3rd Edition UL Standard for Safety for Surge.

B. Suppressor Locations:

1. At point of connection between an equipment item, including ac powered transmitters, and power supply conductor (direct-wired equipment).
2. On analog pairs at each end when the pair travels outside of building.
3. In other locations where equipment sensitivity to surges and transients requires additional protection beyond that inherent to design of equipment.

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C. Suppressor Design:

1. Construction: First-stage, high-energy metal oxide varistor and second-stage, bipolar silicon avalanche device separated by series impedance; includes grounding wire, stud, or terminal.
2. Response: 5 nanoseconds maximum.
3. Recovery: Automatic.
4. Temperature Range: Minus 20 degrees C to plus 85 degrees C.
5. Enclosure Mounted: Encapsulated inflame retardant epoxy.

D. Suppressors on 120V ac Power Supply Connections:

1. Occurrences: Tested and rated for a minimum of 50 occurrences of IEEE C62.41 Category B test waveform.
2. First-Stage Clamping Voltage: 350 volts or less.
3. Second-Stage Clamping Voltage: 210 volts or less.
4. Power Supplies for Continuous Operation:
    a. Four-Wire Transmitter or Receiver: Minimum 5 amps at 130V ac.
    b. All Other Applications: Minimum 30 amps at 130V ac.

E. Suppressors on Analog Signal Lines:

1. Test Waveform: Linear 8-microsecond rise in current from 0 amp to a peak current value followed by an exponential decay of current reaching one-half the peak value in 20 microseconds.
2. Surge Rating: Tested and rated for 50 occurrences of 2,000-amp peak test waveform.
    a. dc Clamping Voltage: 20 percent to 40 percent above operating voltage for circuit.
    b. dc Clamping Voltage Tolerance: Plus or minus 10 percent.
    c. Maximum Loop Resistance: 18 ohms per conductor.

F. Manufacturers and Products:

1. Analog Signals Lines: Emerson Edco PC-642 or SRA-64 series.
2. 120V ac Lines: Emerson Edco HSP-121.
3. 480-Volt, Three-Phase Power Supplies: Square D Model SDSA3650.
4. Field Mounted at Two-Wire Instruments:
    a. Encapsulated in stainless steel pipe nipples.
    b. Emerson Edco SS64 series.
5. Field Mounted at Four-Wire Instruments: With 120V ac outlet, ac circuit breaker, and 10-ohm resistor on signal line, all in enclosure.

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a. Enclosure:
   1) NEMA 4X Type 304 stainless steel with door.
   2) Maximum Size: 12 inches by 12 inches by 8 inches deep.
b. Emerson Edco; SLAC series.

G. Grounding:

1. Coordinate surge suppressor grounding in field panels and field instrumentation with manufacturer's requirements.
2. Provide control panels with an integral copper grounding bus for connection of suppressors and other required instrumentation.

2.09 UNINTERRUPTIBLE POWER SUPPLY

A. Provide UPS and Extended Battery as identified in Supplement UPS List for each panel assembly. Note: UPS for Maintenance Building Network Computer Hardware and Server Cabinets provided under Division 26.

1. Configuration: Tower.
2. Operation: Double conversion.
3. Voltage: 120-volt in; 120-volt out.
4. Carry PLCs for a minimum of 15 minutes.

B. Provide wiring, circuit protection, power chords, battery connection cables, grounding, and control interfaces as identified on Drawings and Supplement UPS List.

C. Except for the UPS in the Administration Building, mount UPS and extended battery within local control panel. Note UPS power local control panel and local NIP.

2.10 CORROSION PROTECTION

A. Corrosion-Inhibiting Vapor Capsules:

1. Use corrosion inhibiting vapor capsules in enclosures to protect components from corrosion.
2. Manufacturers and Products:
   a. Northern Instruments; Model Zerust VC.
   b. Hoffmann Engineering; Model A-HCI.

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2.11 SPARES

A. One set of corrosion inhibitor per panel.

B. Spare care of touch-up paints.

C. Circuit fuse (one of each type).

2.12 SOURCE QUALITY CONTROL

A. General:

1. CH2M HILL may actively participate in the tests.
2. CH2M HILL reserves the right to test or retest specified functions.
3. CH2M HILL's decision will be final regarding acceptability and completeness of testing.
4. Procedures, Forms, and Checklists:
    a. Except for Unwitnessed Factory Test, conduct tests in accordance with, and documented on, reviewed and accepted procedures, forms, and checklists.
    b. Describe each test item to be performed.
    c. Have space after each test item description for sign off by appropriate party after satisfactory completion.
5. Required Test Documentation: Test procedures, forms, and checklists signed by CH2M HILL.
6. Conducting Tests:
    a. Provide special testing materials and equipment.
    b. Provide suitable means of simulation of test inputs and outputs.
    c. Define simulation techniques in test procedures.
    d. Test Format: Cause and effect.
        1) Person conducting test initiates an input (cause).
        2) Specific test requirement is satisfied if correct result (effect), occurs.
    e. Provide sufficient temporary software configuring to allow FDT testing.

B. Unwitnessed Factory Test:

1. Scope: Inspect and test panels to ensure it is operational, ready for FDT.
2. Location: Panel Supplier's facility.

C. Factory Demonstration Tests (FDT):

1. Notify CH2M HILL of test schedule in advance to start of test.
2. Scope: Test entire control panel to demonstrate it is operational.
3. Location: Panel Supplier's facility.

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4. Temporary Application Software: Provide application software to allow PLC and network testing including communications and input/output tests.
5. Correctness of wiring from panel field terminals to PLC system input/output points and to panel components.
    a. Simulate each discrete signal at terminal strip.
    b. Simulate correctness of each analog signal using current source.
6. Operation of communications between PLCs and remote I/O and between PLCs and Ethernet devices.
7. Correct deficiencies found and complete prior to shipment to Site.
8. Failed Tests: Repeat and witnessed by CH2M HILL.
9. Make following documentation available to CH2M HILL at test site both before and during FDT:
    a. Drawings, Specifications, Addenda, and Change Orders.
    b. Master copy of FDT procedures.
    c. List of equipment to be tested including make, model, and serial number.
    d. Approved hardware Shop Drawings for equipment being tested.
10. Daily Schedule for FDT:
    a. Begin each day with meeting to review day's test schedule.
    b. End each day with each meeting to review day's test results and to review or revise next day's test schedule.

PART 3 EXECUTION

3.01 CIRCUIT IDENTIFICATION

A. Identify power, instrumentation, and control conductors at each termination.

B. Assign circuit name based on device or equipment at load end of circuit. Use project equipment and instrument tagging standard.

1. Examples:
    a. Individual Power Conductors: Each power conductor from THDMCC07501 to THDSPLCP07501 shall be labeled "THDSPLCP07501(P)." Phases will be designated only by color coding as described above.
    b. Multi-Conductor Power Cable: The cable from THDMCC07501 to THDSPLCP07501 shall be labeled "THDSPLCP07501(P)." Phases will be designated only by color coding as described above.
    c. Individual Instrument Power Cables: Each power cable from THDTFAIT07501 to THDLCP07501 shall be labeled "THDTFAIT07501 (P)." Conductor will be designated by color coding. Label each power conductor as shown on Typical Control Panel IO Drawings 009-I-2607 through 009-I-2610.

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d. Multi-Conductor Control Cables: The control cable from DG2DSFV08504 to DG2LCP08504 shall be labeled "DG2DSFV08504 (C)." Conductor will be designated by color coding. Label each control cable conductor as shown on Typical Control Panel IO Drawings 009-I-2607 through 009-I-2610.
e. Twisted Pair and Triad Cables: The cable from THDTFAIT07501 to THDLCP07501shall be labeled " THDTFAIT07501(A)." Conductor will be designated by color coding. Label each instrument conductor as shown on Typical Control Panel IO Drawings 009-I-2607 through 009-I-2610.
f. Fiber Optic Cables: The cable between THDNIP07501 and BLWNIP03501 shall be labeled "THDNIP07501/ BLWNIP03501 (F)."

2. Receptacle and lighting circuits shall not require circuit labeling.

C. Method:

1. Conductors 3 AWG and Smaller: Identify with sleeves or heat bond markers.
2. Cables and Conductors 2 AWG and Larger:
   a. Identify with marker plates or tie-on cable marker tags.
   b. Attach with nylon tie cord.
3. Taped-on markers or tags relying on adhesives not permitted.

3.02 SUPPLEMENT

A. The supplement listed below, following "End of Section," is a part of this Specification:

1. Supplement Control Panel List.
2. Supplement UPS List.
3. Supplement Control Panel Non-PLC Equipment List.

END OF SECTION

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CONTROL PANEL SCHEDULE

Cutter Lateral WTP

Panel No.	P&ID	Service (Location)	Mounting	NEMA 250 Rating	Dimensions (Nominal) H	W	D	FDT	Fan	Space Heater	Serv. Lights, Outlets	Environment	SS	NOTES
LCP-300-01	080-I-2002	FILTER AREA PLC	Free Standing pad mounted	Nema 12	70"	72"	24"	Yes	Yes	No	Yes	Inside Heated	Yes	1
LCP-300-02	080-I-2002	DATA Concentrator PLC Panel	Wall Mount											
LCP-280-01	080-I-2003	Sludge Collector 1 & 2 Control Panel	Wall Mount	Nema 4X	30"	24"	8"			Yes	Yes	Inside Heated	Yes	VENDOR SUPPLIED
LCP-380-01	080-I-2004	CHEMICAL FACILITY PLC	Free Standing pad mounted	Nema 12	70"	72"	24"	Yes	Yes	No	Yes	Inside Heated	Yes	1
LCP-380-02	080-I-0016	Sludge Collector 1 & 2 Control Panel	Wall Mount	Nema 4X	30"	24"	8"	Yes		Yes	Yes	Inside Heated	Yes	VENDOR SUPPLIED
LCP-380-02	080-I-0019	Truck Unloading Panel at Sulfuric Acid Tank Tank	Free Standing pad mounted	Nema 4XP	24"	24"	8"	Yes	No	No	No	Outside	no	Fiberglass
LCP-380-03	080-I-0020	Truck Unloading Panel at Ferric Chloride Tank	Free Standing pad mounted	Nema 4XP	24"	24"	8"	Yes	No	No	No	Outside	no	Fiberglass
LCP-380-04	080-I-0021	Truck Unloading Panel at Sodium Hypochlorite Storage Tank	Free Standing pad mounted	Nema 4XP	24"	24"	8"	Yes	No	No	No	Outside	no	Fiberglass
LCP-380-05	080-I-0022	Truck Unloading Panel at Sodium Hydroxide Storage Tank	Free Standing pad mounted	Nema 4XP	24"	24"	8"	Yes	No	No	No	Outside	no	Fiberglass
LCP-300-03	080-I-0028	Truck Unloading Panel at CO2 Storage Tank	Free Standing pad mounted	Nema 4X	24"	24"	8"	Yes	No	No	No	Outside	no	
200-NIP-01	080-I-2001	Ops Building Network Interface Panel	Free Standing	Nema 12										
LCP-300-02	080-I-2001	DATA Concentrator PLC Panel	Wall Mount											for telemetry Points
CHEM-NIP-380-01	080-I-2002	Chemical Building Network Interface Panel												
PROC-NIP-300-01	080-I-2003	Process Building Network Interface Panel												
ELE-NIP-400-01	080-I-2004	Electrical Building Network Interface Panel												
ACP-280-01	080-I-0001/080-I-3012	Raw Water Plant Influent Turbidity Panel	Wall Mount	Nema 4X	72"	36"	18"							turb
ACP-280-02	080-I-0002/080-I-3013	Flocc Sed Basin 1 Analyzer Panel	Wall Mount	Nema 4X	72"	36"	18"							ph & Turb
ACP-280-03	080-I-0003/080-I-3014	Flocc Sed Basin 2 Analyzer Panel	Wall Mount	Nema 4X	72"	36"	18"							ph & Turb
ACP-300-01	080-I-0004/080-I-3012	Filter Influent Analyzer Panel	Wall Mount	Nema 4X	72"	36"	18"							ph & Turb
ACP-300-02	080-I-0005/080-I-3012	Filter 1 Analyzer Panel	Wall Mount	Nema 4X	72"	36"	18"							Turb
ACP-300-03	080-I-0006/080-I-3012	Filter 2 Analyzer Panel	Wall Mount	Nema 4X	72"	36"	18"							Turb
ACP-300-04	080-I-0007/080-I-3012	Filter 3 Analyzer Panel	Wall Mount	Nema 4X	72"	36"	18"							Turb
ACP-300-05	080-I-0008/080-I-3012	Filter 4 Analyzer Panel	Wall Mount	Nema 4X	72"	36"	18"							Turb
ACP-360-01	080-I-0013/080-I-3012	Finished Water Analyzer Panel	Wall Mount	Nema 4X	72"	36"	18"							Ph & Cl
ACP-900-01	900-I-0001	Tank 3 Finished water tank Anlayzer Panel	Free Standing pad mounted	Nema 4X										

FDT: Factory Demonstration Test Required

Note 1 All Dimensions: approximate,contractor to layout according to space required to house required equipment.

SS: Stainless Steel Required

Note 2 Vendor Supplied

Note 3 Power line surge suppressors will be provided for all control panels

Note 4 Surge suppressors will be provided for all analog signals that originate outside buildings

Note 5 All field instruments that require a 120-volt power source shall have 120-volt surge suppressors

Note 6 Allow for at least a 20% increase in space requirements

Note 7 Provide 20% spare terminal space

See 40_90_00Sup02IOList for specific IO counts for each Panel

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SECTION 40 92 05
PROGRAMMABLE LOGIC CONTROLLERS

PART 1 GENERAL

1.01 WORK INCLUDED

A. This Section gives the requirements for furnishing programmable logic controllers (PLC) and accessories.

1.02 RELATED SECTIONS

A. Related sections include the following:

1. Division 1, General Requirements.

1.03 SUBMITTALS

A. General: In accordance with Section 01 33 00, Submittal Procedures.

B. Informational Submittals:

1. Operation and Maintenance Information:
   a. In accordance with Section 01 78 23, Operation and Maintenance Data.
   b. Name, address and telephone number of the PLC Supplier's local service representative.
   c. Complete list of supplied PLC components with full model numbers, including spare parts and test equipment provided.
2. Content for Each O&M Manual:
   a. Table of Contents.
   b. Manufacturer's standard product installation/O&M manuals.

1.04 DELIVERY, STORAGE, AND HANDLING

A. In accordance with Section 01 61 00, Common Product Requirements.

B. Packaged at the factory prior to shipment to protect each item from damage during shipment and storage. Containers protected against impact, abrasion, corrosion, discoloration and/or other damages. Clearly label contents of each container and provide information on the required storage conditions necessary for the equipment.

C. Notify CH2M HILL of the storage requirements and recommendations for the equipment prior to shipment.

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D. Prior to shipment, include corrosive inhibitive vapor capsules in shipping containers, and related equipment as recommended by capsule manufacturer.

PART 2 PRODUCTS

2.01 GENERAL

A. Provide PLC components that are listed in the PLC Equipment List in Article Supplements at the end of this Section.

PART 3 EXECUTION

3.01 SUPPLEMENTS

A. The supplements listed below, following "End of Section," are a part of this Specification:

1. PLC Equipment List.
2. PLC I/O List.

END OF SECTION

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PLC Name	Designation	Qty	Model	Manufacturer	Comments
LCP-300-01 Facility 300 Process/Ops Building PLC					
	Central Processing Unit for Modicon M340 Programmable Logic Controller, Advanced Level 2, 4 Mb RAM, USB port, 2-communication ports: Modbus/Serial and Ethernet-Modbus/TCP, includes 8 Mb memory card.	1	BMXP342020	Modicon	
	12-Slot Backplane for Modicon X80 — One slot for Power Supply + 12 slots for single width modules & CPU, NOT DIN-rail-mountable. 503.2 mm x 103.7 mm (19.81 x 4.08 in.).	5	BMXXBP1200	Modicon	
	Power Supply for Modicon X80, 115 / 240 Vac, 36 W.	5	BMXCPS3500	Modicon	
	Modicon X80 Ethernet Fiber Optic Media Converter, Multi Mode converter, LC connectors, up to 2km.	1	BMXNRP0200	Modicon	
	Extension rack Kit 2 extension rack modules BMXXBE1000, one 0.8 m extension cable BMXXBC008K, 1 set of 2 line terminators TSXTLYEX.	2	BMXXBE2005	Modicon	
	Extension rack Module Standard extension module to inter-connect 2 BMXXBPxx00 racks.	0	BMXXBE1000	Modicon	
	1.5 m extension rack cable Extension rack bent cable, 1.5 m long.	2	BMXXBC015K	Modicon	
	Peripheral Remote IO Adapter	0	BMX PRA 0100	Modicon	
	Modicon X80 Discrete DC Input, (16) 24 Vdc	29	BMXDDI1602	Modicon	
	Pre-wired cable with remote TBs or terminal connector	29	??	Modicon	
	Modicon X80 Discrete AC / DC Output, (16) Relays, 24 Vdc or 24…240 Vac, 2 A (Ith), No protection, 20 points terminal block.	16	BMXDRA1605	Modicon	
	Pre-wired cable with remote TBs or terminal connector	16	??	Modicon	
	8 Analog Input module for Modicon X80, High Level Fast Inputs, 8 multi-range (voltage & current) channels, High speed, high resolution, Isolated between channels.	3	BMXAMI0810	Modicon	
	3m cord Analog 28-way	3	BMXFTA300	Modicon	
	Analog Output module for Modicon M340+B850, 8 current channels, high speed, high resolution, no isolation between channels.	2	BMXAMO0802		

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PLC Name	Designation	Qty	Model	Manufacturer	Comments
	Cable for Analog Inputs or Outputs module: (1) FTB terminal block on shielded cable with color coded flying leads, 3 m, for use with BMXAMI0410, BMXAMO0210, BMXAMO0410, BMXAMO0802, BMXAMM0600.	4	BMXFTW301S	Modicon	
LCP-300-02 Facility 300 Process/Ops Building Data Concentrator PLC					
	Central Processing Unit for Modicon M340 Programmable Logic Controller, Advanced Level 2, 4 Mb RAM, USB port, 2-communication ports: Modbus/Serial and Ethernet-Modbus/TCP, includes 8 Mb memory card.	1	BMXP342020	Modicon	
	12-Slot Backplane for Modicon X80 — One slot for Power Supply + 12 slots for single width modules & CPU, NOT DIN-rail-mountable. 503.2 mm x 103.7 mm (19.81 x 4.08 in.).	1	BMXXBP1200	Modicon	
	Power Supply for Modicon X80, 115 / 240 Vac, 36 W.	1	BMXCPS3500	Modicon	
	Modicon X80 Ethernet Fiber Optic Media Converter, Multi Mode converter, LC connectors, up to 2km.	1	BMXNRP0200	Modicon	
	Extension rack Kit 2 extension rack modules BMXXBE1000, one 0.8 m extension cable BMXXBC008K, 1 set of 2 line terminators TSXTLYEX.	0	BMXXBE2005	Modicon	
	Extension rack Module Standard extension module to inter-connect 2 BMXXBPxx00 racks.	0	BMXXBE1000	Modicon	
	1.5 m extension rack cable Extension rack bent cable, 1.5 m long.	0	BMXXBC015K	Modicon	
	Peripheral Remote IO Adapter	0	BMX PRA 0100	Modicon	
	Modicon X80 Discrete DC Input, (16) 24 Vdc	0	BMXDDI1602	Modicon	
	Pre-wired cable with remote TBs or terminal connector	0		Modicon	
	Modicon X80 Discrete AC / DC Output, (16) Relays, 24 Vdc or 24…240 Vac, 2 A (Ith), No protection, 20 points terminal block.	0	BMXDRA1605	Modicon	
	Pre-wired cable with remote TBs or terminal connector	0		Modicon	
	8 Analog Input module for Modicon X80, High Level Fast Inputs, 8 multi-range (voltage & current) channels, High speed, high resolution, Isolated between channels.	0	BMXAMI0810	Modicon	
	3m cord Analog 28-way	0	BMXFTA300	Modicon	

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PLC Name	Designation	Qty	Model	Manufacturer	Comments
	Analog Output module for Modicon M340+B850, 8 current channels, high speed, high resolution, no isolation between channels.	0	BMXAMO0802		
	Cable for Analog Inputs or Outputs module: (1) FTB terminal block on shielded cable with color coded flying leads, 3 m, for use with BMXAMI0410, BMXAMO0210, BMXAMO0410, BMXAMO0802, BMXAMM0600.	0	BMXFTW301S	Modicon	
LCP-380-01 Facility 380 Chemical Building PLC					
	Central Processing Unit for Modicon M340 Programmable Logic Controller, Advanced Level 2, 4 Mb RAM, USB port, 2-communication ports: Modbus/Serial and Ethernet-Modbus/TCP, includes 8 Mb memory card.	1	BMXP342020	Modicon	
	12-Slot Backplane for Modicon X80 — One slot for Power Supply + 12 slots for single width modules & CPU, NOT DIN-rail-mountable. 503.2 mm x 103.7 mm (19.81 x 4.08 in.).	3	BMXXBP1200	Modicon	
	Power Supply for Modicon X80, 115 / 240 Vac, 36 W.	3	BMXCPS3500	Modicon	
	Modicon X80 Ethernet Fiber Optic Media Converter, Multi Mode converter, LC connectors, up to 2km.	3	BMXNRP0200	Modicon	
	Extension rack Kit 2 extension rack modules BMXXBE1000, one 0.8 m extension cable BMXXBC008K, 1 set of 2 line terminators TSXTLYEX.	2	BMXXBE2005	Modicon	
	Extension rack Module Standard extension module to inter-connect 2 BMXXBPxx00 racks.	0	BMXXBE1000	Modicon	
	1.5 m extension rack cable Extension rack bent cable, 1.5 m long.	0	BMXXBC015K	Modicon	
	Peripheral Remote IO Adapter	0	BMX PRA 0100	Modicon	
	Modicon X80 Discrete DC Input, (16) 24 Vdc	12	BMXDDI1602	Modicon	
	Pre-wired cable with remote TBs or terminal connector	12		Modicon	
	Modicon X80 Discrete AC / DC Output, (16) Relays, 24 Vdc or 24…240 Vac, 2 A (Ith), No protection, 20 points terminal block.	4	BMXDRA1605	Modicon	
	Pre-wired cable with remote TBs or terminal connector	4		Modicon	

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PLC Name	Designation	Qty	Model	Manufacturer	Comments
	8 Analog Input module for Modicon X80, High Level Fast Inputs, 8 multi-range (voltage & current) channels, High speed, high resolution, Isolated between channels.	4	BMXAMI0810	Modicon	
	3m cord Analog 28-way	4	BMXFTA300	Modicon	
	Analog Output module for Modicon M340+B850, 8 current channels, high speed, high resolution, no isolation between channels.	4	BMXAMO0802		
	Cable for Analog Inputs or Outputs module: (1) FTB terminal block on shielded cable with color coded flying leads, 3 m, for use with BMXAMI0410, BMXAMO0210, BMXAMO0410, BMXAMO0802, BMXAMM0600.	4	BMXFTW301S	Modicon	

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CS/VFD	PANEL_NO	INST TYPE	FACILITY NUMBER	LOOP	NUMBER	TAG SUFFIX	LOOP_NO	IO_TAG	TAG_NO	LOOP_TITLE	I/O FUNCTION	IO_TYPE	P+ID NO	120vac
	LCP-300-01	AIT	280	100	01		280-100	AIT-280-100-01-TURB	AIT-280-100-01-TURB	RAW WATER TURBIDITY	TURB	AI	080-I-0001	120vac
	LCP-300-01	AIT	280	100	02		280-100	AIT-280-100-02-PH	AIT-280-100-02-PH	RAW WATER PH	PH	AI	080-I-0001	120vac
	LCP-300-01	AIT	280	100	03		280-100	AIT-280-100-03-COND	AIT-280-100-03-COND	RAW WATER CONDUCTIVITY	COND	AI	080-I-0001	120vac
	LCP-300-01	AIT	280	100	04		280-100	AIT-280-100-04-ABS	AIT-280-100-04-ABS	ABSORBANCE	ABS	AI	080-I-0001	120vac
	LCP-300-01	AIT	280	100	05		280-100	AIT-280-100-05-TEMP	AIT-280-100-05-TEMP	RAW WATER TEMP	TEMP	AI	080-I-0001	120vac
	LCP-300-01	AIT	280	100	06		280-100	AIT-280-100-06-TURB	AIT-280-100-06-TURB	RECYCLE WATER TURBIDITY	TURB	AI	080-I-0001	120vac
	LCP-300-01	FCV	280	201	02		280-201	FCV-280-201-02-FAIL	FCV-280-201-02-FAIL	RAPID MIX 2 FLOW CONTROL VALVE FAIL	FAIL	DI	080-I-0001	
	LCP-300-01	FCV	280	201	02		280-201	FCV-280-201-02-REMOTE	FCV-280-201-02-REMOTE	RAPID MIX 2 FLOW CONTROL VALVE IN REMOTE	REMOTE	DI	080-I-0001	
	LCP-300-01	FCV	280	201	02		280-201	FCV-280-201-02-ZC	FCV-280-201-02-ZC	RAPID MIX 2 FLOW CONTROL VALVE POS CMD	ZC	AO	080-I-0001	
	LCP-300-01	FCV	280	201	02		280-201	FCV-280-201-02-ZT	FCV-280-201-02-ZT	RAPID MIX 2 FLOW CONTROL VALVE POSITION	ZT	AI	080-I-0001	
	LCP-300-01	FIT	280	201	01		280-201	FIT-280-201-01-FAIL	FIT-280-201-01-FAIL	RAPID MIX BASIN 2 INFLUENT FLOW	FAIL	DI	080-I-0001	
	LCP-300-01	FIT	280	201	01		280-201	FIT-280-201-01-FLOW	FIT-280-201-01-FLOW	RAPID MIX BASIN 2 INFLUENT FLOW	FLOW	AI	080-I-0001	120vac
	LCP-300-01	FIT	280	201	01		280-201	FIT-280-201-01-PULSE	FIT-280-201-01-PULSE	RAPID MIX BASIN 2 INFLUENT FLOW	PULSE	DI	080-I-0001	
VFD	LCP-300-01	MXR	280	101	03		280-101	MXR-280-101-03-REMOTE	MXR-280-101-03-REMOTE	RAPID MIX 1 VFD 1 REMOTE	REMOTE	ET	080-I-0001	
VFD	LCP-300-01	MXR	280	101	03		280-101	MXR-280-101-03-FAIL	MXR-280-101-03-FAIL	RAPID MIX 1 VFD 1 FAIL	FAIL	ET	080-I-0001	
VFD	LCP-300-01	MXR	280	101	03		280-101	MXR-280-101-03-RUNNING	MXR-280-101-03-RUNNING	RAPID MIX 1 VFD 1 RUNNING	RUNNING	ET	080-I-0001	
VFD	LCP-300-01	MXR	280	101	03		280-101	MXR-280-101-03-START	MXR-280-101-03-START	RAPID MIX 1 VFD 1 START	START	ET	080-I-0001	
VFD	LCP-300-01	MXR	280	101	03		280-101	MXR-280-101-03-SC	MXR-280-101-03-SC	RAPID MIX 1 VFD 1 SPD CMD	SC	ET	080-I-0001	
VFD	LCP-300-01	MXR	280	101	03		280-101	MXR-280-101-03-SI	MXR-280-101-03-SI	RAPID MIX 1 VFD 1 SPD IND	SI	ET	080-I-0001	
VFD	LCP-300-01	MXR	280	101	04		280-101	MXR-280-101-04-REMOTE	MXR-280-101-04-REMOTE	RAPID MIX 1 VFD 2 REMOTE	REMOTE	ET	080-I-0001	
VFD	LCP-300-01	MXR	280	101	04		280-101	MXR-280-101-04-FAIL	MXR-280-101-04-FAIL	RAPID MIX 1 VFD 2 FAIL	FAIL	ET	080-I-0001	
VFD	LCP-300-01	MXR	280	101	04		280-101	MXR-280-101-04-RUNNING	MXR-280-101-04-RUNNING	RAPID MIX 1 VFD 2 RUNNING	RUNNING	ET	080-I-0001	
VFD	LCP-300-01	MXR	280	101	04		280-101	MXR-280-101-04-START	MXR-280-101-04-START	RAPID MIX 1 VFD 2 START	START	ET	080-I-0001	
VFD	LCP-300-01	MXR	280	101	04		280-101	MXR-280-101-04-SC	MXR-280-101-04-SC	RAPID MIX 1 VFD 2 SPD CMD	SC	ET	080-I-0001	
VFD	LCP-300-01	MXR	280	101	04		280-101	MXR-280-101-04-SI	MXR-280-101-04-SI	RAPID MIX 1 VFD 2 SPD IND	SI	ET	080-I-0001	
	LCP-300-01	FIT	280	101	01		280-101	FIT-280-101-01-FAIL	FIT-280-101-01-FAIL	RAPID MIX BASIN 1 INFLUENT FLOW	FAIL	DI	080-I-0001	
	LCP-300-01	FIT	280	101	01		280-101	FIT-280-101-01-FLOW	FIT-280-101-01-FLOW	RAPID MIX BASIN 1 INFLUENT FLOW	FLOW	AI	080-I-0001	120vac
	LCP-300-01	FIT	280	101	01		280-101	FIT-280-101-01-PULSE	FIT-280-101-01-PULSE	RAPID MIX BASIN 1 INFLUENT FLOW	PULSE	DI	080-I-0001	
	LCP-300-01	FCV	280	101	02		280-101	FCV-280-101-02-FAIL	FCV-280-101-02-FAIL	RAPID MIX 1 FLOW CONTROL VALVE FAIL	FAIL	DI	080-I-0001	

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CS/VFD	PANEL_NO	INST TYPE	FACILITY NUMBER	LOOP	NUMBER	TAG SUFFIX	LOOP_NO	IO_TAG	TAG_NO	LOOP_TITLE	I/O FUNCTION	IO_TYPE	P+ID NO	120vac
	LCP-300-01	FCV	280	101	02		280-101	FCV-280-101-02-REMOTE	FCV-280-101-02-REMOTE	RAPID MIX 1 FLOW CONTROL VALVE IN REMOTE	REMOTE	DI	080-I-0001	
	LCP-300-01	FCV	280	101	02		280-101	FCV-280-101-02-ZC	FCV-280-101-02-ZC	RAPID MIX 1 FLOW CONTROL VALVE POS CMD	ZC	AO	080-I-0001	
	LCP-300-01	FCV	280	101	02		280-101	FCV-280-101-02-ZT	FCV-280-101-02-ZT	RAPID MIX 1 FLOW CONTROL VALVE POSITION	ZT	AI	080-I-0001	
VFD	LCP-300-01	MXR	280	201	03		280-201	MXR-280-201-03-REMOTE	MXR-280-201-03-REMOTE	RAPID MIX 2 VFD 1 REMOTE	REMOTE	ET	080-I-0001	
VFD	LCP-300-01	MXR	280	201	03		280-201	MXR-280-201-03-FAIL	MXR-280-201-03-FAIL	RAPID MIX 2 VFD 1 FAIL	FAIL	ET	080-I-0001	
VFD	LCP-300-01	MXR	280	201	03		280-201	MXR-280-201-03-RUNNING	MXR-280-201-03-RUNNING	RAPID MIX 2 VFD 1 RUNNING	RUNNING	ET	080-I-0001	
VFD	LCP-300-01	MXR	280	201	03		280-201	MXR-280-201-03-START	MXR-280-201-03-START	RAPID MIX 2 VFD 1 START	START	ET	080-I-0001	
VFD	LCP-300-01	MXR	280	201	03		280-201	MXR-280-201-03-SC	MXR-280-201-03-SC	RAPID MIX 2 VFD 1 SPD CMD	SC	ET	080-I-0001	
VFD	LCP-300-01	MXR	280	201	03		280-201	MXR-280-201-03-SI	MXR-280-201-03-SI	RAPID MIX 2 VFD 1 SPD IND	SI	ET	080-I-0001	
VFD	LCP-300-01	MXR	280	201	04		280-201	MXR-280-201-04-REMOTE	MXR-280-201-04-REMOTE	RAPID MIX 2 VFD 2 REMOTE	REMOTE	ET	080-I-0001	
VFD	LCP-300-01	MXR	280	201	04		280-201	MXR-280-201-04-FAIL	MXR-280-201-04-FAIL	RAPID MIX 2 VFD 2 FAIL	FAIL	ET	080-I-0001	
VFD	LCP-300-01	MXR	280	201	04		280-201	MXR-280-201-04-RUNNING	MXR-280-201-04-RUNNING	RAPID MIX 2 VFD 2 RUNNING	RUNNING	ET	080-I-0001	
VFD	LCP-300-01	MXR	280	201	04		280-201	MXR-280-201-04-START	MXR-280-201-04-START	RAPID MIX 2 VFD 2 START	START	ET	080-I-0001	
VFD	LCP-300-01	MXR	280	201	04		280-201	MXR-280-201-04-SC	MXR-280-201-04-SC	RAPID MIX 2 VFD 2 SPD CMD	SC	ET	080-I-0001	
VFD	LCP-300-01	MXR	280	201	04		280-201	MXR-280-201-04-SI	MXR-280-201-04-SI	RAPID MIX 2 VFD 2 SPD IND	SI	ET	080-I-0001	
	LCP-300-01	FV	300	107	00		300-107	FV-300-107-00-CLOSE	FV-300-107-00-CLOSE	BWS TO ADSORBER ISOLATION VLV CLOSE CMD	CLOSE	DO	080-I-0012	
	LCP-300-01	FV	300	107	00		300-107	FV-300-107-00-CLOSED	FV-300-107-00-CLOSED	BWS TO ADSORBER ISOLATION VLV CLOSED	CLOSED	DI	080-I-0012	
	LCP-300-01	FV	300	107	00		300-107	FV-300-107-00-FAIL	FV-300-107-00-FAIL	BWS TO ADSORBER ISOLATION VLV FAIL	FAIL	DI	080-I-0012	
	LCP-300-01	FV	300	107	00		300-107	FV-300-107-00-OPEN	FV-300-107-00-OPEN	BWS TO ADSORBER ISOLATION VLV OPEN CMD	OPEN	DO	080-I-0012	
	LCP-300-01	FV	300	107	00		300-107	FV-300-107-00-OPENED	FV-300-107-00-OPENED	BWS TO ADSORBER ISOLATION VLV OPENED	OPENED	DI	080-I-0012	
	LCP-300-01	FV	300	107	00		300-107	FV-300-107-00-REMOTE	FV-300-107-00-REMOTE	BWS TO ADSORBER ISOLATION VLV REMOTE	REMOTE	DI	080-I-0012	
	LCP-300-01	FV	300	105	03		300-105	FV-300-105-03-CLOSE	FV-300-105-03-CLOSE	BWS TO ADSORBER VESSEL 1 VLV CLOSE CMD	CLOSE	DO	080-I-0012	
	LCP-300-01	FV	300	105	03		300-105	FV-300-105-03-CLOSED	FV-300-105-03-CLOSED	BWS TO ADSORBER VESSEL 1 VLV CLOSED	CLOSED	DI	080-I-0012	
	LCP-300-01	FV	300	105	03		300-105	FV-300-105-03-FAIL	FV-300-105-03-FAIL	BWS TO ADSORBER VESSEL 1 VLV FAIL	FAIL	DI	080-I-0012	
	LCP-300-01	FV	300	105	03		300-105	FV-300-105-03-OPEN	FV-300-105-03-OPEN	BWS TO ADSORBER VESSEL 1 VLV OPEN CMD	OPEN	DO	080-I-0012	
	LCP-300-01	FV	300	105	03		300-105	FV-300-105-03-OPENED	FV-300-105-03-OPENED	BWS TO ADSORBER VESSEL 1 VLV OPENED	OPENED	DI	080-I-0012	
	LCP-300-01	FV	300	105	03		300-105	FV-300-105-03-REMOTE	FV-300-105-03-REMOTE	BWS TO ADSORBER VESSEL 1 VLV REMOTE	REMOTE	DI	080-I-0012	
	LCP-300-01	FV	300	106	03		300-106	FV-300-106-03-CLOSE	FV-300-106-03-CLOSE	BWS TO ADSORBER VESSEL 2 VLV CLOSE CMD	CLOSE	DO	080-I-0012	

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CS/VFD	PANEL_NO	INST TYPE	FACILITY NUMBER	LOOP	NUMBER	TAG SUFFIX	LOOP_NO	IO_TAG	TAG_NO	LOOP_TITLE	I/O FUNCTION	IO_TYPE	P+ID NO	120vac
	LCP-300-01	FV	300	106	03		300-106	FV-300-106-03-CLOSED	FV-300-106-03-CLOSED	BWS TO ADSORBER VESSEL 2 VLV CLOSED	CLOSED	DI	080-I-0012	
	LCP-300-01	FV	300	106	03		300-106	FV-300-106-03-FAIL	FV-300-106-03-FAIL	BWS TO ADSORBER VESSEL 2 VLV FAIL	FAIL	DI	080-I-0012	
	LCP-300-01	FV	300	106	03		300-106	FV-300-106-03-OPEN	FV-300-106-03-OPEN	BWS TO ADSORBER VESSEL 2 VLV OPEN CMD	OPEN	DO	080-I-0012	
	LCP-300-01	FV	300	106	03		300-106	FV-300-106-03-OPENED	FV-300-106-03-OPENED	BWS TO ADSORBER VESSEL 2 VLV OPENED	OPENED	DI	080-I-0012	
	LCP-300-01	FV	300	106	03		300-106	FV-300-106-03-REMOTE	FV-300-106-03-REMOTE	BWS TO ADSORBER VESSEL 2 VLV REMOTE	REMOTE	DI	080-I-0012	
	LCP-300-01	AIT	280	103	01		280-103	AIT-280-103-01-PH	AIT-280-103-01-PH	FLOCC BASIN 1 INFLUENT CHANNEL PH	PH	AI	080-I-0002	120vac
VFD	LCP-300-01	MXR	280	104	01		280-104	MXR-280-104-01-REMOTE	MXR-280-104-01-REMOTE	FLOCC BASIN 1 MIXER 1 AND 2 IN REMOTE	REMOTE	ET	080-I-0002	
VFD	LCP-300-01	MXR	280	104	01		280-104	MXR-280-104-01-FAIL	MXR-280-104-01-FAIL	FLOCC BASIN 1 MIXER 1 AND 2 FAIL	FAIL	ET	080-I-0002	
VFD	LCP-300-01	MXR	280	104	01		280-104	MXR-280-104-01-RUNNING	MXR-280-104-01-RUNNING	FLOCC BASIN 1 MIXER 1 AND 2 IN RUNNING	RUNNING	ET	080-I-0002	
VFD	LCP-300-01	MXR	280	104	01		280-104	MXR-280-104-01-SC	MXR-280-104-01-SC	FLOCC BASIN 1 MIXER 1 AND 2 SPD CMD	SC	ET	080-I-0002	
VFD	LCP-300-01	MXR	280	104	01		280-104	MXR-280-104-01-SI	MXR-280-104-01-SI	FLOCC BASIN 1 MIXER 1 AND 2 SPD IND	SI	ET	080-I-0002	
VFD	LCP-300-01	MXR	280	104	01		280-104	MXR-280-104-01-START	MXR-280-104-01-START	FLOCC BASIN 1 MIXER 1 AND 2 START	START	ET	080-I-0002	
VFD	LCP-300-01	MXR	280	104	02		280-104	MXR-280-104-02-REMOTE	MXR-280-104-02-REMOTE	FLOCC BASIN 1 MIXER 3 AND 4 IN REMOTE	REMOTE	ET	080-I-0002	
VFD	LCP-300-01	MXR	280	104	02		280-104	MXR-280-104-02-FAIL	MXR-280-104-02-FAIL	FLOCC BASIN 1 MIXER 3 AND 4 FAIL	FAIL	ET	080-I-0002	
VFD	LCP-300-01	MXR	280	104	02		280-104	MXR-280-104-02-RUNNING	MXR-280-104-02-RUNNING	FLOCC BASIN 1 MIXER 3 AND 4 IN RUNNING	RUNNING	ET	080-I-0002	
VFD	LCP-300-01	MXR	280	104	02		280-104	MXR-280-104-02-SC	MXR-280-104-02-SC	FLOCC BASIN 1 MIXER 3 AND 4 SPD CMD	SC	ET	080-I-0002	
VFD	LCP-300-01	MXR	280	104	02		280-104	MXR-280-104-02-SI	MXR-280-104-02-SI	FLOCC BASIN 1 MIXER 3 AND 4 SPD IND	SI	ET	080-I-0002	
VFD	LCP-300-01	MXR	280	104	02		280-104	MXR-280-104-02-START	MXR-280-104-02-START	FLOCC BASIN 1 MIXER 3 AND 4 START	START	ET	080-I-0002	
VFD	LCP-300-01	MXR	280	104	03		280-104	MXR-280-104-03-REMOTE	MXR-280-104-03-REMOTE	FLOCC BASIN 1 MIXER 5 AND 6 IN REMOTE	REMOTE	ET	080-I-0002	
VFD	LCP-300-01	MXR	280	104	03		280-104	MXR-280-104-03-FAIL	MXR-280-104-03-FAIL	FLOCC BASIN 1 MIXER 5 AND 6 FAIL	FAIL	ET	080-I-0002	
VFD	LCP-300-01	MXR	280	104	03		280-104	MXR-280-104-03-RUNNING	MXR-280-104-03-RUNNING	FLOCC BASIN 1 MIXER 5 AND 6 IN RUNNING	RUNNING	ET	080-I-0002	

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CS/VFD	PANEL_NO	INST TYPE	FACILITY NUMBER	LOOP	NUMBER	TAG SUFFIX	LOOP_NO	IO_TAG	TAG_NO	LOOP_TITLE	I/O FUNCTION	IO_TYPE	P+ID NO	120vac
VFD	LCP-300-01	MXR	280	104	03		280-104	MXR-280-104-03-SC	MXR-280-104-03-SC	FLOCC BASIN 1 MIXER 5 AND 6 SPD CMD	SC	ET	080-I-0002	
VFD	LCP-300-01	MXR	280	104	03		280-104	MXR-280-104-03-SI	MXR-280-104-03-SI	FLOCC BASIN 1 MIXER 5 AND 6 SPD IND	SI	ET	080-I-0002	
VFD	LCP-300-01	MXR	280	104	03		280-104	MXR-280-104-03-START	MXR-280-104-03-START	FLOCC BASIN 1 MIXER 5 AND 6 START	START	ET	080-I-0002	
	LCP-300-01	LIT	280	104	04		280-104	LIT-280-104-04-LEVEL	LIT-280-104-04-LEVEL	FLOCC BASIN 1 LEVEL	LEVEL	AI	080-I-0002	120vac
	LCP-300-01	AIT	280	106	01		280-106	AIT-280-106-01-PH	AIT-280-106-01-PH	SED BASIN 1 EFFLUENT CHANNEL PH	PH	AI	080-I-0002	120vac
	LCP-300-01	AIT	280	106	02		280-106	AIT-280-106-02-TURB	AIT-280-106-02-TURB	SED BASIN 1 EFFLUENT CHANNEL TURBIDITY	TURB	AI	080-I-0002	120vac
	LCP-300-01	FCV	280	107	01		280-107	FCV-280-107-01-ZC	FCV-280-107-01-ZC	SED BASIN 1 SLUDGE COLLECTOR 1 FCV POS CMD	ZC	AO	080-I-0002	120vac
	LCP-300-01	FCV	280	107	01		280-107	FCV-280-107-01-ZT	FCV-280-107-01-ZT	SED BASIN 1 SLUDGE COLLECTOR 1 FCV POS IND	ZT	AI	080-I-0002	
	LCP-300-01	FCV	280	107	01		280-107	FCV-280-107-01-REMOTE	FCV-280-107-01-REMOTE	SED BASIN 1 SLUDGE COLLECTOR 1 FCV IN REMOTE	REMOTE	DI	080-I-0002	
	LCP-300-01	FCV	280	107	01		280-107	FCV-280-107-01-FAIL	FCV-280-107-01-FAIL	SED BASIN 1 SLUDGE COLLECTOR 1 FCV FAIL	FAIL	DI	080-I-0002	
VFD	RIO-380-01	SLC	280	105	01		280-105	SLC-280-105-01-FAIL	SLC-280-105-01-FAIL	SED BASIN 1 SLUDGE COLLECTOR FAIL	FAIL	ET	080-I-0002	
VFD	RIO-380-01	SLC	280	105	01		280-105	SLC-280-105-01-START	SLC-280-105-01-START	SED BASIN 1 SLUDGE COLLECTOR START	START	ET	080-I-0002	
VFD	RIO-380-01	SLC	280	105	01		280-105	SLC-280-105-01-REMOTE	SLC-280-105-01-REMOTE	SED BASIN 1 SLUDGE COLLECTOR IN REMOTE	REMOTE	ET	080-I-0002	
VFD	RIO-380-01	SLC	280	105	01		280-105	SLC-280-105-01-RUNNING	SLC-280-105-01-RUNNING	SED BASIN 1 SLUDGE COLLECTOR RUNNING	RUNNING	ET	080-I-0002	
VFD	RIO-380-01	SLC	280	105	01		280-105	SLC-280-105-01-SC	SLC-280-105-01-SC	SED BASIN 1 SLUDGE COLLECTOR SPD CMD	SC	ET	080-I-0002	
VFD	RIO-380-01	SLC	280	105	01		280-105	SLC-280-105-01-SI	SLC-280-105-01-SI	SED BASIN 1 SLUDGE COLLECTOR SPD IND	SI	ET	080-I-0002	
VFD	RIO-380-01	SLC	280	205	01		280-205	SLC-280-205-01-FAIL	SLC-280-205-01-FAIL	SED BASIN 2 SLUDGE COLLECTOR FAIL	FAIL	ET	080-I-0002	
VFD	RIO-380-01	SLC	280	205	01		280-205	SLC-280-205-01-START	SLC-280-205-01-START	SED BASIN 2 SLUDGE COLLECTOR START	START	ET	080-I-0002	
VFD	RIO-380-01	SLC	280	205	01		280-205	SLC-280-205-01-REMOTE	SLC-280-205-01-REMOTE	SED BASIN 2 SLUDGE COLLECTOR IN REMOTE	REMOTE	ET	080-I-0002	
VFD	RIO-380-01	SLC	280	205	01		280-205	SLC-280-205-01-RUNNING	SLC-280-205-01-RUNNING	SED BASIN 2 SLUDGE COLLECTOR RUNNING	RUNNING	ET	080-I-0002	
VFD	RIO-380-01	SLC	280	205	01		280-205	SLC-280-205-01-SC	SLC-280-205-01-SC	SED BASIN 2 SLUDGE COLLECTOR SPD CMD	SC	ET	080-I-0002	

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CS/VFD	PANEL_NO	INST TYPE	FACILITY NUMBER	LOOP	NUMBER	TAG SUFFIX	LOOP_NO	IO_TAG	TAG_NO	LOOP_TITLE	I/O FUNCTION	IO_TYPE	P+ID NO	120vac
VFD	RIO-380-01	SLC	280	205	01		280-205	SLC-280-205-01-SI	SLC-280-205-01-SI	SED BASIN 2 SLUDGE COLLECTOR SPD IND	SI	ET	080-I-0002	
	LCP-300-01	AIT	280	203	01		280-203	AIT-280-203-01-PH	AIT-280-203-01-PH	FLOCC BASIN 2 INFLUENT CHANNEL PH	PH	AI	080-I-0003	120vac
VFD	LCP-300-01	MXR	280	204	01		280-204	MXR-280-204-01-FAIL	MXR-280-204-01-FAIL	FLOCC BASIN 2 MIXER 1 AND 2 FAIL	FAIL	ET	080-I-0003	
VFD	LCP-300-01	MXR	280	204	01		280-204	MXR-280-204-01-REMOTE	MXR-280-204-01-REMOTE	FLOCC BASIN 2 MIXER 1 AND 2 IN REMOTE	REMOTE	ET	080-I-0003	
VFD	LCP-300-01	MXR	280	204	01		280-204	MXR-280-204-01-RUNNING	MXR-280-204-01-RUNNING	FLOCC BASIN 2 MIXER 1 AND 2 RUNNING	RUNNING	ET	080-I-0003	
VFD	LCP-300-01	MXR	280	204	01		280-204	MXR-280-204-01-SC	MXR-280-204-01-SC	FLOCC BASIN 2 MIXER 1 AND 2 SPD CMD	SC	ET	080-I-0003	
VFD	LCP-300-01	MXR	280	204	01		280-204	MXR-280-204-01-SI	MXR-280-204-01-SI	FLOCC BASIN 2 MIXER 1 AND 2 SPD IND	SI	ET	080-I-0003	
VFD	LCP-300-01	MXR	280	204	01		280-204	MXR-280-204-01-START	MXR-280-204-01-START	FLOCC BASIN 2 MIXER 1 AND 2 START	START	ET	080-I-0003	
VFD	LCP-300-01	MXR	280	204	02		280-204	MXR-280-204-02-FAIL	MXR-280-204-02-FAIL	FLOCC BASIN 2 MIXER 3 AND 4 FAIL	FAIL	ET	080-I-0003	
VFD	LCP-300-01	MXR	280	204	02		280-204	MXR-280-204-02-REMOTE	MXR-280-204-02-REMOTE	FLOCC BASIN 2 MIXER 3 AND 4 IN REMOTE	REMOTE	ET	080-I-0003	
VFD	LCP-300-01	MXR	280	204	02		280-204	MXR-280-204-02-RUNNING	MXR-280-204-02-RUNNING	FLOCC BASIN 2 MIXER 3 AND 4 RUNNING	RUNNING	ET	080-I-0003	
VFD	LCP-300-01	MXR	280	204	02		280-204	MXR-280-204-02-SC	MXR-280-204-02-SC	FLOCC BASIN 2 MIXER 3 AND 4 SPD CMD	SC	ET	080-I-0003	
VFD	LCP-300-01	MXR	280	204	02		280-204	MXR-280-204-02-SI	MXR-280-204-02-SI	FLOCC BASIN 2 MIXER 3 AND 4 SPD IND	SI	ET	080-I-0003	
VFD	LCP-300-01	MXR	280	204	02		280-204	MXR-280-204-02-START	MXR-280-204-02-START	FLOCC BASIN 2 MIXER 3 AND 4 START	START	ET	080-I-0003	
VFD	LCP-300-01	MXR	280	204	03		280-204	MXR-280-204-03-FAIL	MXR-280-204-03-FAIL	FLOCC BASIN 2 MIXER 5 AND 6 FAIL	FAIL	ET	080-I-0003	
VFD	LCP-300-01	MXR	280	204	03		280-204	MXR-280-204-03-REMOTE	MXR-280-204-03-REMOTE	FLOCC BASIN 2 MIXER 5 AND 6 IN REMOTE	REMOTE	ET	080-I-0003	
VFD	LCP-300-01	MXR	280	204	03		280-204	MXR-280-204-03-RUNNING	MXR-280-204-03-RUNNING	FLOCC BASIN 2 MIXER 5 AND 6 RUNNING	RUNNING	ET	080-I-0003	
VFD	LCP-300-01	MXR	280	204	03		280-204	MXR-280-204-03-SC	MXR-280-204-03-SC	FLOCC BASIN 2 MIXER 5 AND 6 SPD CMD	SC	ET	080-I-0003	
VFD	LCP-300-01	MXR	280	204	03		280-204	MXR-280-204-03-SI	MXR-280-204-03-SI	FLOCC BASIN 2 MIXER 5 AND 6 SPD IND	SI	ET	080-I-0003	
VFD	LCP-300-01	MXR	280	204	03		280-204	MXR-280-204-03-START	MXR-280-204-03-START	FLOCC BASIN 2 MIXER 5 AND 6 START	START	ET	080-I-0003	
	LCP-300-01	LIT	280	204	04		280-204	LIT-280-204-04-LEVEL	LIT-280-204-04-LEVEL	FLOCC BASIN 2 LEVEL	LEVEL	AI	080-I-0003	120vac

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CS/VFD	PANEL_NO	INST TYPE	FACILITY NUMBER	LOOP	NUMBER	TAG SUFFIX	LOOP_NO	IO_TAG	TAG_NO	LOOP_TITLE	I/O FUNCTION	IO_TYPE	P+ID NO	120vac
	LCP-300-01	AIT	280	206	01		280-206	AIT-280-206-01-PH	AIT-280-206-01-PH	SED BASIN 2 EFFLUENT CHANNEL PH	PH	AI	080-I-0003	120vac
	LCP-300-01	AIT	280	206	02		280-206	AIT-280-206-02-TURB	AIT-280-206-02-TURB	SED BASIN 2 EFFLUENT CHANNEL TURBIDITY	TURB	AI	080-I-0003	120vac
	LCP-300-01	PMP	280	206	03		280-206	PMP-280-206-03-RUNNING	PMP-280-206-03-RUNNING	SED BASIN 2 SAMPLE PUMP RUNNING	RUNNING	DI	080-I-0003	
	LCP-300-01	FCV	280	207	01		280-207	FCV-280-207-01-ZC	FCV-280-207-01-ZC	SED BASIN 2 SLUDGE COLLECTOR 1 FCV POS CMD	ZC	AO	080-I-0003	120vac
	LCP-300-01	FCV	280	207	01		280-207	FCV-280-207-01-ZT	FCV-280-207-01-ZT	SED BASIN 2 SLUDGE COLLECTOR 1 FCV POS IND	ZT	AI	080-I-0003	
	LCP-300-01	FCV	280	207	01		280-207	FCV-280-207-01-REMOTE	FCV-280-207-01-REMOTE	SED BASIN 2 SLUDGE COLLECTOR 1 FCV IN REMOTE	REMOTE	DI	080-I-0003	
	LCP-300-01	FCV	280	207	01		280-207	FCV-280-207-01-FAIL	FCV-280-207-01-FAIL	SED BASIN 2 SLUDGE COLLECTOR 1 FCV FAIL	FAIL	DI	080-I-0003	
	LCP-300-01	AIT	300	100	01		300-100	AIT-300-100-01-PH	AIT-300-100-01-PH	FILTER INFLUENT CHANNEL PH	PH	AI	080-I-0004	120vac
	LCP-300-01	AIT	300	100	02		300-100	AIT-300-100-02-TURB	AIT-300-100-02-TURB	FILTER INFLUENT CHANNEL TURB	TURB	AI	080-I-0004	120vac
	LCP-300-01	PMP	300	100	03		300-100	PMP-300-100-03-RUNNING	PMP-300-100-03-RUNNING	FILTER INFLUENT CHANNEL SAMPLE PUMP RUNNING	RUNNING	DI	080-I-0004	
	LCP-300-01	LIT	300	100	04		300-100	LIT-300-100-04-LEVEL	LIT-300-100-04-LEVEL	BWW CHANNEL LEVEL	LEVEL	AI	080-I-0004	120vac
	LCP-300-01	LIT	300	100	05		300-100	LIT-300-100-05-LEVEL	LIT-300-100-05-LEVEL	FILTER INFLUENT CHANNEL LEVEL	LEVEL	AI	080-I-0004	120vac
	LCP-300-01	AIT	300	101	01		300-101	AIT-300-101-01-TURB	AIT-300-101-01-TURB	FILTER 1 EFFLUENT TURBIDITY	TURB	AI	080-I-0005	120vac
	LCP-300-01	FIT	300	101	01		300-101	FIT-300-101-01-FAIL	FIT-300-101-01-FAIL	FILTER 1 EFFLUENT FLOW FAIL	FAIL	DI	080-I-0005	
	LCP-300-01	FIT	300	101	01		300-101	FIT-300-101-01-FLOW	FIT-300-101-01-FLOW	FILTER 1 EFFLUENT FLOW	FLOW	AI	080-I-0005	120vac
	LCP-300-01	FIT	300	101	01		300-101	FIT-300-101-01-PULSE	FIT-300-101-01-PULSE	FILTER 1 EFFLUENT FLOW PULSE	PULSE	DI	080-I-0005	
	LCP-300-01	FV	300	101	01		300-101	FV-300-101-01-CLOSE	FV-300-101-01-CLOSE	FILTER 1 INFLUENT VLV CLOSE CMD	CLOSE	DO	080-I-0005	
	LCP-300-01	FV	300	101	01		300-101	FV-300-101-01-CLOSED	FV-300-101-01-CLOSED	FILTER 1 INFLUENT VALVE CLOSED	CLOSED	DI	080-I-0005	
	LCP-300-01	FV	300	101	01		300-101	FV-300-101-01-FAIL	FV-300-101-01-FAIL	FILTER 1 INFLUENT VALVE FAIL	FAIL	DI	080-I-0005	
	LCP-300-01	FV	300	101	01		300-101	FV-300-101-01-OPEN	FV-300-101-01-OPEN	FILTER 1 INFLUENT VLV OPEN CMD	OPEN	DO	080-I-0005	
	LCP-300-01	FV	300	101	01		300-101	FV-300-101-01-OPENED	FV-300-101-01-OPENED	FILTER 1 INFLUENT VALVE OPENED	OPENED	DI	080-I-0005	

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CS/VFD	PANEL_NO	INST TYPE	FACILITY NUMBER	LOOP	NUMBER	TAG SUFFIX	LOOP_NO	IO_TAG	TAG_NO	LOOP_TITLE	I/O FUNCTION	IO_TYPE	P+ID NO	120vac
	LCP-300-01	FV	300	101	01		300-101	FV-300-101-01-REMOTE	FV-300-101-01-REMOTE	FILTER 1 INFLUENT VALVE IN REMOTE	REMOTE	DI	080-I-0005	
	LCP-300-01	LIT	300	101	01		300-101	LIT-300-101-01-LEVEL	LIT-300-101-01-LEVEL	FILTER 1 LEVEL	LEVEL	AI	080-I-0005	120vac
	LCP-300-01	PDIT	300	101	01		300-101	PDIT-300-101-01-D/P	PDIT-300-101-01-D/P	FILTER 1 DP	D/P	AI	080-I-0005	
	LCP-300-01	FV	300	101	02		300-101	FV-300-101-02-CLOSE	FV-300-101-02-CLOSE	FILTER 1 BWW VLV CLOSE CMD	CLOSE	DO	080-I-0005	
	LCP-300-01	FV	300	101	02		300-101	FV-300-101-02-CLOSED	FV-300-101-02-CLOSED	FILTER 1 BWW VALVE CLOSED	CLOSED	DI	080-I-0005	
	LCP-300-01	FV	300	101	02		300-101	FV-300-101-02-FAIL	FV-300-101-02-FAIL	FILTER 1 BWW VALVE FAIL	FAIL	DI	080-I-0005	
	LCP-300-01	FV	300	101	02		300-101	FV-300-101-02-OPEN	FV-300-101-02-OPEN	FILTER 1 BWW VLV OPEN CMD	OPEN	DO	080-I-0005	
	LCP-300-01	FV	300	101	02		300-101	FV-300-101-02-OPENED	FV-300-101-02-OPENED	FILTER 1 BWW VALVE OPENED	OPENED	DI	080-I-0005	
	LCP-300-01	FV	300	101	02		300-101	FV-300-101-02-REMOTE	FV-300-101-02-REMOTE	FILTER 1 BWW VALVE IN REMOTE	REMOTE	DI	080-I-0005	
	LCP-300-01	FV	300	101	03		300-101	FV-300-101-03-CLOSE	FV-300-101-03-CLOSE	FILTER 1 BWS VLV CLOSE CMD	CLOSE	DO	080-I-0005	
	LCP-300-01	FV	300	101	03		300-101	FV-300-101-03-CLOSED	FV-300-101-03-CLOSED	FILTER 1 BWS VALVE CLOSED	CLOSED	DI	080-I-0005	
	LCP-300-01	FV	300	101	03		300-101	FV-300-101-03-FAIL	FV-300-101-03-FAIL	FILTER 1 BWS VALVE FAIL	FAIL	DI	080-I-0005	
	LCP-300-01	FV	300	101	03		300-101	FV-300-101-03-OPEN	FV-300-101-03-OPEN	FILTER 1 BWS VLV OPEN CMD	OPEN	DO	080-I-0005	
	LCP-300-01	FV	300	101	03		300-101	FV-300-101-03-OPENED	FV-300-101-03-OPENED	FILTER 1 BWS VALVE OPENED	OPENED	DI	080-I-0005	
	LCP-300-01	FV	300	101	03		300-101	FV-300-101-03-REMOTE	FV-300-101-03-REMOTE	FILTER 1 BWS VALVE IN REMOTE	REMOTE	DI	080-I-0005	
	LCP-300-01	FV	300	101	04		300-101	FV-300-101-04-CLOSE	FV-300-101-04-CLOSE	FILTER 1 BACKWASH SCOUR AIR SUPPLY VLV CLOSE CMD	CLOSE	DO	080-I-0005	
	LCP-300-01	FV	300	101	04		300-101	FV-300-101-04-CLOSED	FV-300-101-04-CLOSED	FILTER 1 BACKWASH SCOUR AIR SUPPLY VALVE CLOSED	CLOSED	DI	080-I-0005	
	LCP-300-01	FV	300	101	04		300-101	FV-300-101-04-FAIL	FV-300-101-04-FAIL	FILTER 1 BACKWASH SCOUR AIR SUPPLY VALVE FAIL	FAIL	DI	080-I-0005	
	LCP-300-01	FV	300	101	04		300-101	FV-300-101-04-OPEN	FV-300-101-04-OPEN	FILTER 1 BACKWASH SCOUR AIR SUPPLY VLV OPEN CMD	OPEN	DO	080-I-0005	
	LCP-300-01	FV	300	101	04		300-101	FV-300-101-04-OPENED	FV-300-101-04-OPENED	FILTER 1 BACKWASH SCOUR AIR SUPPLY VALVE OPENED	OPENED	DI	080-I-0005	
	LCP-300-01	FV	300	101	04		300-101	FV-300-101-04-REMOTE	FV-300-101-04-REMOTE	FILTER 1 BACKWASH SCOUR AIR SUPPLY VALVE IN REMOTE	REMOTE	DI	080-I-0005	

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CS/VFD	PANEL_NO	INST TYPE	FACILITY NUMBER	LOOP	NUMBER	TAG SUFFIX	LOOP_NO	IO_TAG	TAG_NO	LOOP_TITLE	I/O FUNCTION	IO_TYPE	P+ID NO	120vac
	LCP-300-01	FCV	300	101	05		300-101	FCV-300-101-05-FAIL	FCV-300-101-05-FAIL	FILTER 1 EFFLUENT FLOW CONTROL VALVE FAIL	FAIL	DI	080-I-0005	
	LCP-300-01	FCV	300	101	05		300-101	FCV-300-101-05-REMOTE	FCV-300-101-05-REMOTE	FILTER 1 EFFLUENT FLOW CONTROL VALVE IN REMOTE	REMOTE	DI	080-I-0005	
	LCP-300-01	FCV	300	101	05		300-101	FCV-300-101-05-ZC	FCV-300-101-05-ZC	FILTER 1 EFFLUENT FLOW CONTROL VALVE POS CMD	ZC	AO	080-I-0005	
	LCP-300-01	FCV	300	101	05		300-101	FCV-300-101-05-ZT	FCV-300-101-05-ZT	FILTER 1 EFFLUENT FLOW CONTROL VALVE POSITION	ZT	AI	080-I-0005	
	LCP-300-01	FV	300	101	06		300-101	FV-300-101-06-CLOSE	FV-300-101-06-CLOSE	FILTER 1 EFFLUENT ISOL VLV CLOSE CMD	CLOSE	DO	080-I-0005	
	LCP-300-01	FV	300	101	06		300-101	FV-300-101-06-CLOSED	FV-300-101-06-CLOSED	FILTER 1 EFFLUENT ISOL VALVE CLOSED	CLOSED	DI	080-I-0005	
	LCP-300-01	FV	300	101	06		300-101	FV-300-101-06-FAIL	FV-300-101-06-FAIL	FILTER 1 EFFLUENT ISOL VALVE FAIL	FAIL	DI	080-I-0005	
	LCP-300-01	FV	300	101	06		300-101	FV-300-101-06-OPEN	FV-300-101-06-OPEN	FILTER 1 EFFLUENT ISOL VLV OPEN CMD	OPEN	DO	080-I-0005	
	LCP-300-01	FV	300	101	06		300-101	FV-300-101-06-OPENED	FV-300-101-06-OPENED	FILTER 1 EFFLUENT ISOL VALVE OPENED	OPENED	DI	080-I-0005	
	LCP-300-01	FV	300	101	06		300-101	FV-300-101-06-REMOTE	FV-300-101-06-REMOTE	FILTER 1 EFFLUENT ISOL VALVE IN REMOTE	REMOTE	DI	080-I-0005	
	LCP-300-01	FV	300	101	07		300-101	FV-300-101-07-CLOSE	FV-300-101-07-CLOSE	FILTER 1 FTW VLV CLOSE CMD	CLOSE	DO	080-I-0005	
	LCP-300-01	FV	300	101	07		300-101	FV-300-101-07-CLOSED	FV-300-101-07-CLOSED	FILTER 1 FTW VALVE CLOSED	CLOSED	DI	080-I-0005	
	LCP-300-01	FV	300	101	07		300-101	FV-300-101-07-FAIL	FV-300-101-07-FAIL	FILTER 1 FTW VALVE FAIL	FAIL	DI	080-I-0005	
	LCP-300-01	FV	300	101	07		300-101	FV-300-101-07-OPEN	FV-300-101-07-OPEN	FILTER 1 FTW VLV OPEN CMD	OPEN	DO	080-I-0005	
	LCP-300-01	FV	300	101	07		300-101	FV-300-101-07-OPENED	FV-300-101-07-OPENED	FILTER 1 FTW VALVE OPENED	OPENED	DI	080-I-0005	
	LCP-300-01	FV	300	101	07		300-101	FV-300-101-07-REMOTE	FV-300-101-07-REMOTE	FILTER 1 FTW VALVE IN REMOTE	REMOTE	DI	080-I-0005	
	LCP-300-01	AIT	300	102	01		300-102	AIT-300-102-01-TURB	AIT-300-102-01-TURB	FILTER 2 EFFLUENT TURBIDITY	TURB	AI	080-I-0006	120vac
	LCP-300-01	FIT	300	102	01		300-102	FIT-300-102-01-FAIL	FIT-300-102-01-FAIL	FILTER 2 EFFLUENT FLOW FAIL	FAIL	DI	080-I-0006	
	LCP-300-01	FIT	300	102	01		300-102	FIT-300-102-01-FLOW	FIT-300-102-01-FLOW	FILTER 2 EFFLUENT FLOW	FLOW	AI	080-I-0006	120vac
	LCP-300-01	FIT	300	102	01		300-102	FIT-300-102-01-PULSE	FIT-300-102-01-PULSE	FILTER 2 EFFLUENT FLOW PULSE	PULSE	DI	080-I-0006	
	LCP-300-01	FV	300	102	01		300-102	FV-300-102-01-CLOSE	FV-300-102-01-CLOSE	FILTER 2 INFLUENT VLV CLOSE CMD	CLOSE	DO	080-I-0006	

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CS/VFD	PANEL_NO	INST TYPE	FACILITY NUMBER	LOOP	NUMBER	TAG SUFFIX	LOOP_NO	IO_TAG	TAG_NO	LOOP_TITLE	I/O FUNCTION	IO_TYPE	P+ID NO	120vac
	LCP-300-01	FV	300	102	01		300-102	FV-300-102-01-CLOSED	FV-300-102-01-CLOSED	FILTER 2 INFLUENT VALVE CLOSED	CLOSED	DI	080-I-0006	
	LCP-300-01	FV	300	102	01		300-102	FV-300-102-01-FAIL	FV-300-102-01-FAIL	FILTER 2 INFLUENT VALVE FAIL	FAIL	DI	080-I-0006	
	LCP-300-01	FV	300	102	01		300-102	FV-300-102-01-OPEN	FV-300-102-01-OPEN	FILTER 2 INFLUENT VLV OPEN CMD	OPEN	DO	080-I-0006	
	LCP-300-01	FV	300	102	01		300-102	FV-300-102-01-OPENED	FV-300-102-01-OPENED	FILTER 2 INFLUENT VALVE OPENED	OPENED	DI	080-I-0006	
	LCP-300-01	FV	300	102	01		300-102	FV-300-102-01-REMOTE	FV-300-102-01-REMOTE	FILTER 2 INFLUENT VALVE IN REMOTE	REMOTE	DI	080-I-0006	
	LCP-300-01	LIT	300	102	01		300-102	LIT-300-102-01-LEVEL	LIT-300-102-01-LEVEL	FILTER 2 LEVEL	LEVEL	AI	080-I-0006	120vac
	LCP-300-01	PDIT	300	102	01		300-102	PDIT-300-102-01-D/P	PDIT-300-102-01-D/P	FILTER 2 DP	D/P	AI	080-I-0006	
	LCP-300-01	FV	300	102	02		300-102	FV-300-102-02-CLOSE	FV-300-102-02-CLOSE	FILTER 2 BWW VLV CLOSE CMD	CLOSE	DO	080-I-0006	
	LCP-300-01	FV	300	102	02		300-102	FV-300-102-02-CLOSED	FV-300-102-02-CLOSED	FILTER 2 BWW VALVE CLOSED	CLOSED	DI	080-I-0006	
	LCP-300-01	FV	300	102	02		300-102	FV-300-102-02-FAIL	FV-300-102-02-FAIL	FILTER 2 BWW VALVE FAIL	FAIL	DI	080-I-0006	
	LCP-300-01	FV	300	102	02		300-102	FV-300-102-02-OPEN	FV-300-102-02-OPEN	FILTER 2 BWW VLV OPEN CMD	OPEN	DO	080-I-0006	
	LCP-300-01	FV	300	102	02		300-102	FV-300-102-02-OPENED	FV-300-102-02-OPENED	FILTER 2 BWW VALVE OPENED	OPENED	DI	080-I-0006	
	LCP-300-01	FV	300	102	02		300-102	FV-300-102-02-REMOTE	FV-300-102-02-REMOTE	FILTER 2 BWW VALVE IN REMOTE	REMOTE	DI	080-I-0006	
	LCP-300-01	FV	300	102	03		300-102	FV-300-102-03-CLOSE	FV-300-102-03-CLOSE	FILTER 2 BWS VLV CLOSE CMD	CLOSE	DO	080-I-0006	
	LCP-300-01	FV	300	102	03		300-102	FV-300-102-03-CLOSED	FV-300-102-03-CLOSED	FILTER 2 BWS VALVE CLOSED	CLOSED	DI	080-I-0006	
	LCP-300-01	FV	300	102	03		300-102	FV-300-102-03-FAIL	FV-300-102-03-FAIL	FILTER 2 BWS VALVE FAIL	FAIL	DI	080-I-0006	
	LCP-300-01	FV	300	102	03		300-102	FV-300-102-03-OPEN	FV-300-102-03-OPEN	FILTER 2 BWS VLV OPEN CMD	OPEN	DO	080-I-0006	
	LCP-300-01	FV	300	102	03		300-102	FV-300-102-03-OPENED	FV-300-102-03-OPENED	FILTER 2 BWS VALVE OPENED	OPENED	DI	080-I-0006	
	LCP-300-01	FV	300	102	03		300-102	FV-300-102-03-REMOTE	FV-300-102-03-REMOTE	FILTER 2 BWS VALVE IN REMOTE	REMOTE	DI	080-I-0006	
	LCP-300-01	FV	300	102	04		300-102	FV-300-102-04-CLOSE	FV-300-102-04-CLOSE	FILTER 2 BACKWASH SCOUR AIR SUPPLY VLV CLOSE CMD	CLOSE	DO	080-I-0006	
	LCP-300-01	FV	300	102	04		300-102	FV-300-102-04-CLOSED	FV-300-102-04-CLOSED	FILTER 2 BACKWASH SCOUR AIR SUPPLY VALVE CLOSED	CLOSED	DI	080-I-0006	

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CS/VFD	PANEL_NO	INST TYPE	FACILITY NUMBER	LOOP	NUMBER	TAG SUFFIX	LOOP_NO	IO_TAG	TAG_NO	LOOP_TITLE	I/O FUNCTION	IO_TYPE	P+ID NO	120vac
	LCP-300-01	FV	300	102	04		300-102	FV-300-102-04-FAIL	FV-300-102-04-FAIL	FILTER 2 BACKWASH SCOUR AIR SUPPLY VALVE FAIL	FAIL	DI	080-I-0006	
	LCP-300-01	FV	300	102	04		300-102	FV-300-102-04-OPEN	FV-300-102-04-OPEN	FILTER 2 BACKWASH SCOUR AIR SUPPLY VLV OPEN CMD	OPEN	DO	080-I-0006	
	LCP-300-01	FV	300	102	04		300-102	FV-300-102-04-OPENED	FV-300-102-04-OPENED	FILTER 2 BACKWASH SCOUR AIR SUPPLY VALVE OPENED	OPENED	DI	080-I-0006	
	LCP-300-01	FV	300	102	04		300-102	FV-300-102-04-REMOTE	FV-300-102-04-REMOTE	FILTER 2 BACKWASH SCOUR AIR SUPPLY VALVE IN REMOTE	REMOTE	DI	080-I-0006	
	LCP-300-01	FCV	300	102	05		300-102	FCV-300-102-05-FAIL	FCV-300-102-05-FAIL	FILTER 2 EFFLUENT FLOW CONTROL VALVE FAIL	FAIL	DI	080-I-0006	
	LCP-300-01	FCV	300	102	05		300-102	FCV-300-102-05-REMOTE	FCV-300-102-05-REMOTE	FILTER 2 EFFLUENT FLOW CONTROL VALVE IN REMOTE	REMOTE	DI	080-I-0006	
	LCP-300-01	FCV	300	102	05		300-102	FCV-300-102-05-ZC	FCV-300-102-05-ZC	FILTER 2 EFFLUENT FLOW CONTROL VALVE POS CMD	ZC	AO	080-I-0006	
	LCP-300-01	FCV	300	102	05		300-102	FCV-300-102-05-ZT	FCV-300-102-05-ZT	FILTER 2 EFFLUENT FLOW CONTROL VALVE POSITION	ZT	AI	080-I-0006	
	LCP-300-01	FV	300	102	06		300-102	FV-300-102-06-CLOSE	FV-300-102-06-CLOSE	FILTER 2 EFFLUENT ISOL VLV CLOSE CMD	CLOSE	DO	080-I-0006	
	LCP-300-01	FV	300	102	06		300-102	FV-300-102-06-CLOSED	FV-300-102-06-CLOSED	FILTER 2 EFFLUENT ISOL VALVE CLOSED	CLOSED	DI	080-I-0006	
	LCP-300-01	FV	300	102	06		300-102	FV-300-102-06-FAIL	FV-300-102-06-FAIL	FILTER 2 EFFLUENT ISOL VALVE FAIL	FAIL	DI	080-I-0006	
	LCP-300-01	FV	300	102	06		300-102	FV-300-102-06-OPEN	FV-300-102-06-OPEN	FILTER 2 EFFLUENT ISOL VLV OPEN CMD	OPEN	DO	080-I-0006	
	LCP-300-01	FV	300	102	06		300-102	FV-300-102-06-OPENED	FV-300-102-06-OPENED	FILTER 2 EFFLUENT ISOL VALVE OPENED	OPENED	DI	080-I-0006	
	LCP-300-01	FV	300	102	06		300-102	FV-300-102-06-REMOTE	FV-300-102-06-REMOTE	FILTER 2 EFFLUENT ISOL VALVE IN REMOTE	REMOTE	DI	080-I-0006	
	LCP-300-01	FV	300	102	07		300-102	FV-300-102-07-CLOSE	FV-300-102-07-CLOSE	FILTER 2 FTW VLV CLOSE CMD	CLOSE	DO	080-I-0006	
	LCP-300-01	FV	300	102	07		300-102	FV-300-102-07-CLOSED	FV-300-102-07-CLOSED	FILTER 2 FTW VALVE CLOSED	CLOSED	DI	080-I-0006	
	LCP-300-01	FV	300	102	07		300-102	FV-300-102-07-FAIL	FV-300-102-07-FAIL	FILTER 2 FTW VALVE FAIL	FAIL	DI	080-I-0006	
	LCP-300-01	FV	300	102	07		300-102	FV-300-102-07-OPEN	FV-300-102-07-OPEN	FILTER 2 FTW VLV OPEN CMD	OPEN	DO	080-I-0006	
	LCP-300-01	FV	300	102	07		300-102	FV-300-102-07-OPENED	FV-300-102-07-OPENED	FILTER 2 FTW VALVE OPENED	OPENED	DI	080-I-0006	
	LCP-300-01	FV	300	102	07		300-102	FV-300-102-07-REMOTE	FV-300-102-07-REMOTE	FILTER 2 FTW VALVE IN REMOTE	REMOTE	DI	080-I-0006	
	LCP-300-01	AIT	300	103	01		300-103	AIT-300-103-01-TURB	AIT-300-103-01-TURB	FILTER 3 EFFLUENT TURBIDITY	TURB	AI	080-I-0007	120vac

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CS/VFD	PANEL_NO	INST TYPE	FACILITY NUMBER	LOOP	NUMBER	TAG SUFFIX	LOOP_NO	IO_TAG	TAG_NO	LOOP_TITLE	I/O FUNCTION	IO_TYPE	P+ID NO	120vac
	LCP-300-01	FIT	300	103	01		300-103	FIT-300-103-01-FAIL	FIT-300-103-01-FAIL	FILTER 3 EFFLUENT FLOW FAIL	FAIL	DI	080-I-0007	
	LCP-300-01	FIT	300	103	01		300-103	FIT-300-103-01-FLOW	FIT-300-103-01-FLOW	FILTER 3 EFFLUENT FLOW	FLOW	AI	080-I-0007	120vac
	LCP-300-01	FIT	300	103	01		300-103	FIT-300-103-01-PULSE	FIT-300-103-01-PULSE	FILTER 3 EFFLUENT FLOW PULSE	PULSE	DI	080-I-0007	
	LCP-300-01	FV	300	103	01		300-103	FV-300-103-01-CLOSE	FV-300-103-01-CLOSE	FILTER 3 INFLUENT VLV CLOSE CMD	CLOSE	DO	080-I-0007	
	LCP-300-01	FV	300	103	01		300-103	FV-300-103-01-CLOSED	FV-300-103-01-CLOSED	FILTER 3 INFLUENT VALVE CLOSED	CLOSED	DI	080-I-0007	
	LCP-300-01	FV	300	103	01		300-103	FV-300-103-01-FAIL	FV-300-103-01-FAIL	FILTER 3 INFLUENT VALVE FAIL	FAIL	DI	080-I-0007	
	LCP-300-01	FV	300	103	01		300-103	FV-300-103-01-OPEN	FV-300-103-01-OPEN	FILTER 3 INFLUENT VLV OPEN CMD	OPEN	DO	080-I-0007	
	LCP-300-01	FV	300	103	01		300-103	FV-300-103-01-OPENED	FV-300-103-01-OPENED	FILTER 3 INFLUENT VALVE OPENED	OPENED	DI	080-I-0007	
	LCP-300-01	FV	300	103	01		300-103	FV-300-103-01-REMOTE	FV-300-103-01-REMOTE	FILTER 3 INFLUENT VALVE IN REMOTE	REMOTE	DI	080-I-0007	
	LCP-300-01	LIT	300	103	01		300-103	LIT-300-103-01-LEVEL	LIT-300-103-01-LEVEL	FILTER 3 LEVEL	LEVEL	AI	080-I-0007	120vac
	LCP-300-01	PDIT	300	103	01		300-103	PDIT-300-103-01-D/P	PDIT-300-103-01-D/P	FILTER 3 DP	D/P	AI	080-I-0007	
	LCP-300-01	FV	300	103	02		300-103	FV-300-103-02-CLOSE	FV-300-103-02-CLOSE	FILTER 3 BWW VLV CLOSE CMD	CLOSE	DO	080-I-0007	
	LCP-300-01	FV	300	103	02		300-103	FV-300-103-02-CLOSED	FV-300-103-02-CLOSED	FILTER 3 BWW VALVE CLOSED	CLOSED	DI	080-I-0007	
	LCP-300-01	FV	300	103	02		300-103	FV-300-103-02-FAIL	FV-300-103-02-FAIL	FILTER 3 BWW VALVE FAIL	FAIL	DI	080-I-0007	
	LCP-300-01	FV	300	103	02		300-103	FV-300-103-02-OPEN	FV-300-103-02-OPEN	FILTER 3 BWW VLV OPEN CMD	OPEN	DO	080-I-0007	
	LCP-300-01	FV	300	103	02		300-103	FV-300-103-02-OPENED	FV-300-103-02-OPENED	FILTER 3 BWW VALVE OPENED	OPENED	DI	080-I-0007	
	LCP-300-01	FV	300	103	02		300-103	FV-300-103-02-REMOTE	FV-300-103-02-REMOTE	FILTER 3 BWW VALVE IN REMOTE	REMOTE	DI	080-I-0007	
	LCP-300-01	FV	300	103	03		300-103	FV-300-103-03-CLOSE	FV-300-103-03-CLOSE	FILTER 3 BWS VLV CLOSE CMD	CLOSE	DO	080-I-0007	
	LCP-300-01	FV	300	103	03		300-103	FV-300-103-03-CLOSED	FV-300-103-03-CLOSED	FILTER 3 BWS VALVE CLOSED	CLOSED	DI	080-I-0007	
	LCP-300-01	FV	300	103	03		300-103	FV-300-103-03-FAIL	FV-300-103-03-FAIL	FILTER 3 BWS VALVE FAIL	FAIL	DI	080-I-0007	
	LCP-300-01	FV	300	103	03		300-103	FV-300-103-03-OPEN	FV-300-103-03-OPEN	FILTER 3 BWS VLV OPEN CMD	OPEN	DO	080-I-0007	

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CS/VFD	PANEL_NO	INST TYPE	FACILITY NUMBER	LOOP	NUMBER	TAG SUFFIX	LOOP_NO	IO_TAG	TAG_NO	LOOP_TITLE	I/O FUNCTION	IO_TYPE	P+ID NO	120vac
	LCP-300-01	FV	300	103	03		300-103	FV-300-103-03-OPENED	FV-300-103-03-OPENED	FILTER 3 BWS VALVE OPENED	OPENED	DI	080-I-0007	
	LCP-300-01	FV	300	103	03		300-103	FV-300-103-03-REMOTE	FV-300-103-03-REMOTE	FILTER 3 BWS VALVE IN REMOTE	REMOTE	DI	080-I-0007	
	LCP-300-01	FV	300	103	04		300-103	FV-300-103-04-CLOSE	FV-300-103-04-CLOSE	FILTER 3 BACKWASH SCOUR AIR SUPPLY VLV CLOSE CMD	CLOSE	DO	080-I-0007	
	LCP-300-01	FV	300	103	04		300-103	FV-300-103-04-CLOSED	FV-300-103-04-CLOSED	FILTER 3 BACKWASH SCOUR AIR SUPPLY VALVE CLOSED	CLOSED	DI	080-I-0007	
	LCP-300-01	FV	300	103	04		300-103	FV-300-103-04-FAIL	FV-300-103-04-FAIL	FILTER 3 BACKWASH SCOUR AIR SUPPLY VALVE FAIL	FAIL	DI	080-I-0007	
	LCP-300-01	FV	300	103	04		300-103	FV-300-103-04-OPEN	FV-300-103-04-OPEN	FILTER 3 BACKWASH SCOUR AIR SUPPLY VLV OPEN CMD	OPEN	DO	080-I-0007	
	LCP-300-01	FV	300	103	04		300-103	FV-300-103-04-OPENED	FV-300-103-04-OPENED	FILTER 3 BACKWASH SCOUR AIR SUPPLY VALVE OPENED	OPENED	DI	080-I-0007	
	LCP-300-01	FV	300	103	04		300-103	FV-300-103-04-REMOTE	FV-300-103-04-REMOTE	FILTER 3 BACKWASH SCOUR AIR SUPPLY VALVE IN REMOTE	REMOTE	DI	080-I-0007	
	LCP-300-01	FCV	300	103	05		300-103	FCV-300-103-05-FAIL	FCV-300-103-05-FAIL	FILTER 3 EFFLUENT FLOW CONTROL VALVE FAIL	FAIL	DI	080-I-0007	
	LCP-300-01	FCV	300	103	05		300-103	FCV-300-103-05-REMOTE	FCV-300-103-05-REMOTE	FILTER 3 EFFLUENT FLOW CONTROL VALVE IN REMOTE	REMOTE	DI	080-I-0007	
	LCP-300-01	FCV	300	103	05		300-103	FCV-300-103-05-ZC	FCV-300-103-05-ZC	FILTER 3 EFFLUENT FLOW CONTROL VALVE POS CMD	ZC	AO	080-I-0007	
	LCP-300-01	FCV	300	103	05		300-103	FCV-300-103-05-ZT	FCV-300-103-05-ZT	FILTER 3 EFFLUENT FLOW CONTROL VALVE POSITION	ZT	AI	080-I-0007	
	LCP-300-01	FV	300	103	06		300-103	FV-300-103-06-CLOSE	FV-300-103-06-CLOSE	FILTER 3 EFFLUENT ISOL VLV CLOSE CMD	CLOSE	DO	080-I-0007	
	LCP-300-01	FV	300	103	06		300-103	FV-300-103-06-CLOSED	FV-300-103-06-CLOSED	FILTER 3 EFFLUENT ISOL VALVE CLOSED	CLOSED	DI	080-I-0007	
	LCP-300-01	FV	300	103	06		300-103	FV-300-103-06-FAIL	FV-300-103-06-FAIL	FILTER 3 EFFLUENT ISOL VALVE FAIL	FAIL	DI	080-I-0007	
	LCP-300-01	FV	300	103	06		300-103	FV-300-103-06-OPEN	FV-300-103-06-OPEN	FILTER 3 EFFLUENT ISOL VLV OPEN CMD	OPEN	DO	080-I-0007	
	LCP-300-01	FV	300	103	06		300-103	FV-300-103-06-OPENED	FV-300-103-06-OPENED	FILTER 3 EFFLUENT ISOL VALVE OPENED	OPENED	DI	080-I-0007	
	LCP-300-01	FV	300	103	06		300-103	FV-300-103-06-REMOTE	FV-300-103-06-REMOTE	FILTER 3 EFFLUENT ISOL VALVE IN REMOTE	REMOTE	DI	080-I-0007	
	LCP-300-01	FV	300	103	07		300-103	FV-300-103-07-CLOSE	FV-300-103-07-CLOSE	FILTER 3 FTW VLV CLOSE CMD	CLOSE	DO	080-I-0007	
	LCP-300-01	FV	300	103	07		300-103	FV-300-103-07-CLOSED	FV-300-103-07-CLOSED	FILTER 3 FTW VALVE CLOSED	CLOSED	DI	080-I-0007	
	LCP-300-01	FV	300	103	07		300-103	FV-300-103-07-FAIL	FV-300-103-07-FAIL	FILTER 3 FTW VALVE FAIL	FAIL	DI	080-I-0007	

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CS/VFD	PANEL_NO	INST TYPE	FACILITY NUMBER	LOOP	NUMBER	TAG SUFFIX	LOOP_NO	IO_TAG	TAG_NO	LOOP_TITLE	I/O FUNCTION	IO_TYPE	P+ID NO	120vac
	LCP-300-01	FV	300	103	07		300-103	FV-300-103-07-OPEN	FV-300-103-07-OPEN	FILTER 3 FTW VLV OPEN CMD	OPEN	DO	080-I-0007	
	LCP-300-01	FV	300	103	07		300-103	FV-300-103-07-OPENED	FV-300-103-07-OPENED	FILTER 3 FTW VALVE OPENED	OPENED	DI	080-I-0007	
	LCP-300-01	FV	300	103	07		300-103	FV-300-103-07-REMOTE	FV-300-103-07-REMOTE	FILTER 3 FTW VALVE IN REMOTE	REMOTE	DI	080-I-0007	
	LCP-300-01	AIT	300	104	01		300-104	AIT-300-104-01-TURB	AIT-300-104-01-TURB	FILTER 3 EFFLUENT TURBIDITY	TURB	AI	080-I-0008	120vac
	LCP-300-01	FIT	300	104	01		300-104	FIT-300-104-01-FAIL	FIT-300-104-01-FAIL	FILTER 4 EFFLUENT FLOW FAIL	FAIL	DI	080-I-0008	
	LCP-300-01	FIT	300	104	01		300-104	FIT-300-104-01-FLOW	FIT-300-104-01-FLOW	FILTER 4 EFFLUENT FLOW	FLOW	AI	080-I-0008	120vac
	LCP-300-01	FIT	300	104	01		300-104	FIT-300-104-01-PULSE	FIT-300-104-01-PULSE	FILTER 4 EFFLUENT FLOW PULSE	PULSE	DI	080-I-0008	
	LCP-300-01	FV	300	104	01		300-104	FV-300-104-01-CLOSE	FV-300-104-01-CLOSE	FILTER 4 EFFLUENT ISOL VALVE CLOSE CMD	CLOSE	DO	080-I-0008	
	LCP-300-01	FV	300	104	01		300-104	FV-300-104-01-CLOSED	FV-300-104-01-CLOSED	FILTER 4 EFFLUENT ISOL VALVE CLOSED	CLOSED	DI	080-I-0008	
	LCP-300-01	FV	300	104	01		300-104	FV-300-104-01-FAIL	FV-300-104-01-FAIL	FILTER 4 EFFLUENT ISOL VLV FAIL	FAIL	DI	080-I-0008	
	LCP-300-01	FV	300	104	01		300-104	FV-300-104-01-OPEN	FV-300-104-01-OPEN	FILTER 4 EFFLUENT ISOL VALVE OPEN CMD	OPEN	DO	080-I-0008	
	LCP-300-01	FV	300	104	01		300-104	FV-300-104-01-OPENED	FV-300-104-01-OPENED	FILTER 4 EFFLUENT ISOL VALVE OPENED	OPENED	DI	080-I-0008	
	LCP-300-01	FV	300	104	01		300-104	FV-300-104-01-REMOTE	FV-300-104-01-REMOTE	FILTER 4 BACKWASH SCOUR AIR SUPPLY VLV REMOTE	REMOTE	DI	080-I-0008	
	LCP-300-01	LIT	300	104	01		300-104	LIT-300-104-01-LEVEL	LIT-300-104-01-LEVEL	FILTER 4 LEVEL	LEVEL	AI	080-I-0008	120vac
	LCP-300-01	PDIT	300	104	01		300-104	PDIT-300-104-01-D/P	PDIT-300-104-01-D/P	FILTER 4 DP	D/P	AI	080-I-0008	
	LCP-300-01	FV	300	104	02		300-104	FV-300-104-02-CLOSE	FV-300-104-02-CLOSE	FILTER 4 BACKWASH SCOUR AIR SUPPLY VALVE CLOSE CMD	CLOSE	DO	080-I-0008	
	LCP-300-01	FV	300	104	02		300-104	FV-300-104-02-CLOSED	FV-300-104-02-CLOSED	FILTER 4 BACKWASH SCOUR AIR SUPPLY VALVE CLOSED	CLOSED	DI	080-I-0008	
	LCP-300-01	FV	300	104	02		300-104	FV-300-104-02-FAIL	FV-300-104-02-FAIL	FILTER 4 BACKWASH SCOUR AIR SUPPLY VLV FAIL	FAIL	DI	080-I-0008	
	LCP-300-01	FV	300	104	02		300-104	FV-300-104-02-OPEN	FV-300-104-02-OPEN	FILTER 4 BACKWASH SCOUR AIR SUPPLY VALVE OPEN CMD	OPEN	DO	080-I-0008	
	LCP-300-01	FV	300	104	02		300-104	FV-300-104-02-OPENED	FV-300-104-02-OPENED	FILTER 4 BACKWASH SCOUR AIR SUPPLY VALVE OPENED	OPENED	DI	080-I-0008	
	LCP-300-01	FV	300	104	02		300-104	FV-300-104-02-REMOTE	FV-300-104-02-REMOTE	FILTER 4 EFFLUENT FLOW CONTROL VALVE REMOTE	REMOTE	DI	080-I-0008	

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CS/VFD	PANEL_NO	INST TYPE	FACILITY NUMBER	LOOP	NUMBER	TAG SUFFIX	LOOP_NO	IO_TAG	TAG_NO	LOOP_TITLE	I/O FUNCTION	IO_TYPE	P+ID NO	120vac
	LCP-300-01	FV	300	104	03		300-104	FV-300-104-03-CLOSE	FV-300-104-03-CLOSE	FILTER 4 INFLUENT VALVE CLOSE CMD	CLOSE	DO	080-I-0008	
	LCP-300-01	FV	300	104	03		300-104	FV-300-104-03-CLOSED	FV-300-104-03-CLOSED	FILTER 4 INFLUENT VALVE IN CLOSED	CLOSED	DI	080-I-0008	
	LCP-300-01	FV	300	104	03		300-104	FV-300-104-03-FAIL	FV-300-104-03-FAIL	FILTER 4 BWS VLVFAIL	FAIL	DI	080-I-0008	
	LCP-300-01	FV	300	104	03		300-104	FV-300-104-03-OPEN	FV-300-104-03-OPEN	FILTER 4 BWS VALVE OPEN CMD	OPEN	DO	080-I-0008	
	LCP-300-01	FV	300	104	03		300-104	FV-300-104-03-OPENED	FV-300-104-03-OPENED	FILTER 4 BWS VALVE OPENED	OPENED	DI	080-I-0008	
	LCP-300-01	FV	300	104	03		300-104	FV-300-104-03-REMOTE	FV-300-104-03-REMOTE	FILTER 4 BWS VLV REMOTE	REMOTE	DI	080-I-0008	
	LCP-300-01	FV	300	104	04		300-104	FV-300-104-04-CLOSE	FV-300-104-04-CLOSE	FILTER 4 BACKWASH SCOUR AIR SUPPLY VLV CLOSE CMD	CLOSE	DO	080-I-0008	
	LCP-300-01	FV	300	104	04		300-104	FV-300-104-04-CLOSED	FV-300-104-04-CLOSED	FILTER 4 BACKWASH SCOUR AIR SUPPLY VALVE CLOSED	CLOSED	DI	080-I-0008	
	LCP-300-01	FV	300	104	04		300-104	FV-300-104-04-FAIL	FV-300-104-04-FAIL	FILTER 4 BACKWASH SCOUR AIR SUPPLY VALVE FAIL	FAIL	DI	080-I-0008	
	LCP-300-01	FV	300	104	04		300-104	FV-300-104-04-OPEN	FV-300-104-04-OPEN	FILTER 4 BACKWASH SCOUR AIR SUPPLY VLV OPEN CMD	OPEN	DO	080-I-0008	
	LCP-300-01	FV	300	104	04		300-104	FV-300-104-04-OPENED	FV-300-104-04-OPENED	FILTER 4 BACKWASH SCOUR AIR SUPPLY VALVE OPENED	OPENED	DI	080-I-0008	
	LCP-300-01	FV	300	104	04		300-104	FV-300-104-04-REMOTE	FV-300-104-04-REMOTE	FILTER 4 BACKWASH SCOUR AIR SUPPLY VALVE IN REMOTE	REMOTE	DI	080-I-0008	
	LCP-300-01	FCV	300	104	05		300-104	FCV-300-104-05-FAIL	FCV-300-104-05-FAIL	FILTER 4 EFFLUENT FLOW CONTROL VALVE FAIL	FAIL	DI	080-I-0008	
	LCP-300-01	FCV	300	104	05		300-104	FCV-300-104-05-REMOTE	FCV-300-104-05-REMOTE	FILTER 4 EFFLUENT FLOW CONTROL VALVE IN REMOTE	REMOTE	DI	080-I-0008	
	LCP-300-01	FCV	300	104	05		300-104	FCV-300-104-05-ZC	FCV-300-104-05-ZC	FILTER 4 EFFLUENT FLOW CONTROL VALVE POS CMD	ZC	AO	080-I-0008	
	LCP-300-01	FCV	300	104	05		300-104	FCV-300-104-05-ZT	FCV-300-104-05-ZT	FILTER 4 EFFLUENT FLOW CONTROL VALVE POSITION	ZT	AI	080-I-0008	
	LCP-300-01	FV	300	104	06		300-104	FV-300-104-06-CLOSE	FV-300-104-06-CLOSE	FILTER 4 EFFLUENT ISOL VLV CLOSE CMD	CLOSE	DO	080-I-0008	
	LCP-300-01	FV	300	104	06		300-104	FV-300-104-06-CLOSED	FV-300-104-06-CLOSED	FILTER 4 EFFLUENT ISOL VALVE CLOSED	CLOSED	DI	080-I-0008	
	LCP-300-01	FV	300	104	06		300-104	FV-300-104-06-FAIL	FV-300-104-06-FAIL	FILTER 4 EFFLUENT ISOL VALVE FAIL	FAIL	DI	080-I-0008	
	LCP-300-01	FV	300	104	06		300-104	FV-300-104-06-OPEN	FV-300-104-06-OPEN	FILTER 4 EFFLUENT ISOL VLV OPEN CMD	OPEN	DO	080-I-0008	
	LCP-300-01	FV	300	104	06		300-104	FV-300-104-06-OPENED	FV-300-104-06-OPENED	FILTER 4 EFFLUENT ISOL VALVE OPENED	OPENED	DI	080-I-0008	

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CS/VFD	PANEL_NO	INST TYPE	FACILITY NUMBER	LOOP	NUMBER	TAG SUFFIX	LOOP_NO	IO_TAG	TAG_NO	LOOP_TITLE	I/O FUNCTION	IO_TYPE	P+ID NO	120vac
	LCP-300-01	FV	300	104	06		300-104	FV-300-104-06-REMOTE	FV-300-104-06-REMOTE	FILTER 4 EFFLUENT ISOL VALVE IN REMOTE	REMOTE	DI	080-I-0008	
	LCP-300-01	FV	300	104	07		300-104	FV-300-104-07-CLOSE	FV-300-104-07-CLOSE	FILTER 4 BWW VALVE OPEN CMD	CLOSE	DO	080-I-0008	
	LCP-300-01	FV	300	104	07		300-104	FV-300-104-07-CLOSED	FV-300-104-07-CLOSED	FILTER 4 BWW VALVE IN CLOSED	CLOSED	DI	080-I-0008	
	LCP-300-01	FV	300	104	07		300-104	FV-300-104-07-FAIL	FV-300-104-07-FAIL	FILTER 4 INFLUENT VLV FAIL	FAIL	DI	080-I-0008	
	LCP-300-01	FV	300	104	07		300-104	FV-300-104-07-OPEN	FV-300-104-07-OPEN	FILTER 4 INFLUENT VALVE CLOSE CMD	OPEN	DO	080-I-0008	
	LCP-300-01	FV	300	104	07		300-104	FV-300-104-07-OPENED	FV-300-104-07-OPENED	FILTER 4 INFLUENT VALVE OPENED	OPENED	DI	080-I-0008	
	LCP-300-01	FV	300	104	07		300-104	FV-300-104-07-REMOTE	FV-300-104-07-REMOTE	FILTER 4 INFLUENT VLV REMOTE	REMOTE	DI	080-I-0008	
	LCP-300-01	BLW	300	001	01		300-1	BLW-300-001-01-HI D/P	BLW-300-001-01-HI D/P	AIR SCOUR BLOWER 1 INLET FILTER HI D/P	HI D/P	DI	080-I-0009	
CS	LCP-300-01	BLW	300	001	01		300-1	BLW-300-001-01-FAIL	BLW-300-001-01-FAIL	AIR SCOUR BLOWER 1 FAIL	FAIL	ET	080-I-0009	
CS	LCP-300-01	BLW	300	001	01		300-1	BLW-300-001-01-REMOTE	BLW-300-001-01-REMOTE	AIR SCOUR BLOWER 1 REMOTE	REMOTE	ET	080-I-0009	
CS	LCP-300-01	BLW	300	001	01		300-1	BLW-300-001-01-RUNNING	BLW-300-001-01-RUNNING	AIR SCOUR BLOWER 1 RUNNING	RUNNING	ET	080-I-0009	
CS	LCP-300-01	BLW	300	001	01		300-1	BLW-300-001-01-START	BLW-300-001-01-START	AIR SCOUR BLOWER 1 START	START	ET	080-I-0009	
CS	LCP-300-01	BLW	300	001	01		300-1	BLW-300-001-01-TSH	BLW-300-001-01-TSH	AIR SCOUR BLOWER 1 HIGH WINDING TEMP	TSH	ET	080-I-0009	
	LCP-300-01	BLW	300	001	01		300-1	BLW-300-001-01-TSH	BLW-300-001-01-TSH	AIR SCOUR BLOWER 1 DISCHG HI TEMP	TSH	DI	080-I-0009	
CS	LCP-300-01	BLW	300	001	02		300-1	BLW-300-001-02-FAIL	BLW-300-001-02-FAIL	AIR SCOUR BLOWER 2 FAIL	FAIL	ET	080-I-0009	
CS	LCP-300-01	BLW	300	001	02		300-1	BLW-300-001-02-REMOTE	BLW-300-001-02-REMOTE	AIR SCOUR BLOWER 2 REMOTE	REMOTE	ET	080-I-0009	
CS	LCP-300-01	BLW	300	001	02		300-1	BLW-300-001-02-RUNNING	BLW-300-001-02-RUNNING	AIR SCOUR BLOWER 2 RUNNING	RUNNING	ET	080-I-0009	
CS	LCP-300-01	BLW	300	001	02		300-1	BLW-300-001-02-START	BLW-300-001-02-START	AIR SCOUR BLOWER 2 START	START	ET	080-I-0009	
CS	LCP-300-01	BLW	300	001	02		300-1	BLW-300-001-02-TSH	BLW-300-001-02-TSH	AIR SCOUR BLOWER 2 HIGH WINDING TEMP	TSH	ET	080-I-0009	
	LCP-300-01	BLW	300	001	02		300-1	BLW-300-001-02-HI D/P	BLW-300-001-02-HI D/P	AIR SCOUR BLOWER 2 INLET FILTER HI D/P	HI D/P	DI	080-I-0009	
	LCP-300-01	BLW	300	001	02		300-1	BLW-300-001-02-TSH	BLW-300-001-02-TSH	AIR SCOUR BLOWER 2 DISCHG HI TEMP	TSH	DI	080-I-0009	

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CS/VFD	PANEL_NO	INST TYPE	FACILITY NUMBER	LOOP	NUMBER	TAG SUFFIX	LOOP_NO	IO_TAG	TAG_NO	LOOP_TITLE	I/O FUNCTION	IO_TYPE	P+ID NO	120vac
	LCP-300-01	FCV	300	003	03		300-3	FCV-300-003-03-REMOTE	FCV-300-003-03-REMOTE	AIR SCOUR FCV TO OUTSIDE IN REMOTE	REMOTE	DI	080-I-0009	
	LCP-300-01	FCV	300	003	03		300-3	FCV-300-003-03-ZC	FCV-300-003-03-ZC	AIR SCOUR FCV TO OUTSIDE POS CMD	ZC	AI	080-I-0009	
	LCP-300-01	FCV	300	003	03		300-3	FCV-300-003-03-ZT	FCV-300-003-03-ZT	AIR SCOUR FCV TO OUTSIDE POSITION	ZT	AI	080-I-0009	
	LCP-300-01	FCV	300	003	03		300-3	FCV-300-003-03-FAIL	FCV-300-003-03-FAIL	AIR SCOUR FCV TO OUTSIDE FAIL	FAIL	DI	080-I-0009	
	LCP-300-01	FIT	300	003	04		300-3	FIT-300-003-04-FAIL	FIT-300-003-04-FAIL	AIR SCOUR COMBINED DISCHG FLOW FAIL	FAIL	DI	080-I-0009	
	LCP-300-01	FIT	300	001	04		300-1	FIT-300-001-04-FLOW	FIT-300-001-04-FLOW	AIR SCOUR COMBINED DISCHG FLOW	FLOW	AI	080-I-0009	120vac
	LCP-300-01	FIT	300	001	04		300-1	FIT-300-001-04-PULSE	FIT-300-001-04-PULSE	AIR SCOUR COMBINED DISCHG FLOW PULSE	PULSE	DI	080-I-0009	
	LCP-300-01	FIT	300	105	05		300-105	FIT-300-105-05-FAIL	FIT-300-105-05-FAIL	FILTER EFFLUENT FLOW TO GAC PUMP SUCTION FAIL	FAIL	DI	080-I-0011	
	LCP-300-01	FIT	300	105	05		300-105	FIT-300-105-05-FLOW	FIT-300-105-05-FLOW	FILTER EFFLUENT FLOW TO GAC PUMP SUCTION FLOW	FLOW	AI	080-I-0011	120vac
	LCP-300-01	FIT	300	105	05		300-105	FIT-300-105-05-PULSE	FIT-300-105-05-PULSE	FILTER EFFLUENT FLOW TO GAC PUMP SUCTION PULSE	PULSE	DI	080-I-0011	
	LCP-300-01	PMP	300	101	01		300-101	PMP-300-101-01-RUNNING	PMP-300-101-01-RUNNING	FILTER INFLUENT SAMPLE PUMP RUNNING	RUNNING	DI	080-I-0010	
	LCP-300-01	PMP	300	101	02		300-101	PMP-300-101-02-RUNNING	PMP-300-101-02-RUNNING	GAC EFFLUENT SAMPLE PUMP RUNNING	RUNNING	DI	080-I-0010	
	LCP-300-01	SWR	300	104	01		300-104	SWR-300-104-01-FSH	SWR-300-104-01-FSH	CHEMICAL INJECTION SAFTEY SHOWER	FSH	DI	080-I-0010	
	LCP-300-01	PIT	300	105	04		300-105	PIT-300-105-04-PRESS	PIT-300-105-04-PRESS	GAC SUPPLY PUMPS COMBINED DISCHARGE PRESSURE	PRESS	AI	080-I-0011	
	LCP-300-01	FV	300	106	04		300-106	FV-300-106-04-CLOSE	FV-300-106-04-CLOSE	GAC ADSORBER VESSEL 2 TO BWW VLV CLOSE CMD	CLOSE	DO	080-I-0012	
	LCP-300-01	FV	300	106	04		300-106	FV-300-106-04-CLOSED	FV-300-106-04-CLOSED	GAC ADSORBER VESSEL 2 TO BWW VLV CLOSED	CLOSED	DI	080-I-0012	
	LCP-300-01	FV	300	106	04		300-106	FV-300-106-04-FAIL	FV-300-106-04-FAIL	GAC ADSORBER VESSEL 2 TO BWW VLV FAIL	FAIL	DI	080-I-0012	
	LCP-300-01	FV	300	106	04		300-106	FV-300-106-04-OPEN	FV-300-106-04-OPEN	GAC ADSORBER VESSEL 2 TO BWW VLV OPEN CMD	OPEN	DO	080-I-0012	
	LCP-300-01	FV	300	106	04		300-106	FV-300-106-04-OPENED	FV-300-106-04-OPENED	GAC ADSORBER VESSEL 2 TO BWW VLV OPENED	OPENED	DI	080-I-0012	
	LCP-300-01	FV	300	106	04		300-106	FV-300-106-04-REMOTE	FV-300-106-04-REMOTE	GAC ADSORBER VESSEL 2 TO BWW VLV REMOTE	REMOTE	DI	080-I-0012	
	LCP-300-01	FV	300	105	04		300-105	FV-300-105-04-CLOSE	FV-300-105-04-CLOSE	GAC ADSORBER VESSEL 1 TO BWW VLV CLOSE CMD	CLOSE	DO	080-I-0012	

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CS/VFD	PANEL_NO	INST TYPE	FACILITY NUMBER	LOOP	NUMBER	TAG SUFFIX	LOOP_NO	IO_TAG	TAG_NO	LOOP_TITLE	I/O FUNCTION	IO_TYPE	P+ID NO	120vac
	LCP-300-01	FV	300	105	04		300-105	FV-300-105-04-CLOSED	FV-300-105-04-CLOSED	GAC ADSORBER VESSEL 1 TO BWW VLV CLOSED	CLOSED	DI	080-I-0012	
	LCP-300-01	FV	300	105	04		300-105	FV-300-105-04-FAIL	FV-300-105-04-FAIL	GAC ADSORBER VESSEL 1 TO BWW VLV FAIL	FAIL	DI	080-I-0012	
	LCP-300-01	FV	300	105	04		300-105	FV-300-105-04-OPEN	FV-300-105-04-OPEN	GAC ADSORBER VESSEL 1 TO BWW VLV OPEN CMD	OPEN	DO	080-I-0012	
	LCP-300-01	FV	300	105	04		300-105	FV-300-105-04-OPENED	FV-300-105-04-OPENED	GAC ADSORBER VESSEL 1 TO BWW VLV OPENED	OPENED	DI	080-I-0012	
	LCP-300-01	FV	300	105	04		300-105	FV-300-105-04-REMOTE	FV-300-105-04-REMOTE	GAC ADSORBER VESSEL 1 TO BWW VLV REMOTE	REMOTE	DI	080-I-0012	
	LCP-300-01	FV	300	106	01		300-106	FV-300-106-01-CLOSE	FV-300-106-01-CLOSE	GAC PUMPS TO ADSORBER VESSEL 2 VLV CLOSE CMD	CLOSE	DO	080-I-0012	
	LCP-300-01	FV	300	106	01		300-106	FV-300-106-01-CLOSED	FV-300-106-01-CLOSED	GAC PUMPS TO ADSORBER VESSEL 2 VLV CLOSED	CLOSED	DI	080-I-0012	
	LCP-300-01	FV	300	106	01		300-106	FV-300-106-01-FAIL	FV-300-106-01-FAIL	GAC PUMPS TO ADSORBER VESSEL 2 VLV FAIL	FAIL	DI	080-I-0012	
	LCP-300-01	FV	300	106	01		300-106	FV-300-106-01-OPEN	FV-300-106-01-OPEN	GAC PUMPS TO ADSORBER VESSEL 2 VLV OPEN CMD	OPEN	DO	080-I-0012	
	LCP-300-01	FV	300	106	01		300-106	FV-300-106-01-OPENED	FV-300-106-01-OPENED	GAC PUMPS TO ADSORBER VESSEL 2 VLV OPENED	OPENED	DI	080-I-0012	
	LCP-300-01	FV	300	106	01		300-106	FV-300-106-01-REMOTE	FV-300-106-01-REMOTE	GAC PUMPS TO ADSORBER VESSEL 2 VLV REMOTE	REMOTE	DI	080-I-0012	
	LCP-300-01	FV	300	105	01		300-105	FV-300-105-01-CLOSE	FV-300-105-01-CLOSE	GAC PUMPS TO ADSORBER VESSEL 1 VLV CLOSE CMD	CLOSE	DO	080-I-0012	
	LCP-300-01	FV	300	105	01		300-105	FV-300-105-01-CLOSED	FV-300-105-01-CLOSED	GAC PUMPS TO ADSORBER VESSEL 1 VLV CLOSED	CLOSED	DI	080-I-0012	
	LCP-300-01	FV	300	105	01		300-105	FV-300-105-01-FAIL	FV-300-105-01-FAIL	GAC PUMPS TO ADSORBER VESSEL 1 VLV FAIL	FAIL	DI	080-I-0012	
	LCP-300-01	FV	300	105	01		300-105	FV-300-105-01-OPEN	FV-300-105-01-OPEN	GAC PUMPS TO ADSORBER VESSEL 1 VLV OPEN CMD	OPEN	DO	080-I-0012	
	LCP-300-01	FV	300	105	01		300-105	FV-300-105-01-OPENED	FV-300-105-01-OPENED	GAC PUMPS TO ADSORBER VESSEL 1 VLV OPENED	OPENED	DI	080-I-0012	
	LCP-300-01	FV	300	105	01		300-105	FV-300-105-01-REMOTE	FV-300-105-01-REMOTE	GAC PUMPS TO ADSORBER VESSEL 1 VLV REMOTE	REMOTE	DI	080-I-0012	
	LCP-300-01	FV	300	106	05		300-106	FV-300-106-05-CLOSE	FV-300-106-05-CLOSE	ADSORBER VESSEL 1 TO VESSEL 2 VLV CLOSE CMD	CLOSE	DO	080-I-0012	
	LCP-300-01	FV	300	106	05		300-106	FV-300-106-05-CLOSED	FV-300-106-05-CLOSED	ADSORBER VESSEL 1 TO VESSEL 2 VLV CLOSED	CLOSED	DI	080-I-0012	
	LCP-300-01	FV	300	106	05		300-106	FV-300-106-05-FAIL	FV-300-106-05-FAIL	ADSORBER VESSEL 1 TO VESSEL 2 VLV FAIL	FAIL	DI	080-I-0012	
	LCP-300-01	FV	300	106	05		300-106	FV-300-106-05-OPEN	FV-300-106-05-OPEN	ADSORBER VESSEL 1 TO VESSEL 2 VLV OPEN CMD	OPEN	DO	080-I-0012	

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CS/VFD	PANEL_NO	INST TYPE	FACILITY NUMBER	LOOP	NUMBER	TAG SUFFIX	LOOP_NO	IO_TAG	TAG_NO	LOOP_TITLE	I/O FUNCTION	IO_TYPE	P+ID NO	120vac
	LCP-300-01	FV	300	106	05		300-106	FV-300-106-05-OPENED	FV-300-106-05-OPENED	ADSORBER VESSEL 1 TO VESSEL 2 VLV OPENED	OPENED	DI	080-I-0012	
	LCP-300-01	FV	300	106	05		300-106	FV-300-106-05-REMOTE	FV-300-106-05-REMOTE	ADSORBER VESSEL 1 TO VESSEL 2 VLV REMOTE	REMOTE	DI	080-I-0012	
	LCP-300-01	FV	300	105	05		300-105	FV-300-105-05-CLOSE	FV-300-105-05-CLOSE	ADSORBER VESSEL 2 TO VESSEL 1 VLV CLOSE CMD	CLOSE	DO	080-I-0012	
	LCP-300-01	FV	300	105	05		300-105	FV-300-105-05-CLOSED	FV-300-105-05-CLOSED	ADSORBER VESSEL 2 TO VESSEL 1 VLV CLOSED	CLOSED	DI	080-I-0012	
	LCP-300-01	FV	300	105	05		300-105	FV-300-105-05-FAIL	FV-300-105-05-FAIL	ADSORBER VESSEL 2 TO VESSEL 1 VLV FAIL	FAIL	DI	080-I-0012	
	LCP-300-01	FV	300	105	05		300-105	FV-300-105-05-OPEN	FV-300-105-05-OPEN	ADSORBER VESSEL 2 TO VESSEL 1 VLV OPEN CMD	OPEN	DO	080-I-0012	
	LCP-300-01	FV	300	105	05		300-105	FV-300-105-05-OPENED	FV-300-105-05-OPENED	ADSORBER VESSEL 2 TO VESSEL 1 VLV OPENED	OPENED	DI	080-I-0012	
	LCP-300-01	FV	300	105	05		300-105	FV-300-105-05-REMOTE	FV-300-105-05-REMOTE	ADSORBER VESSEL 2 TO VESSEL 1 VLV REMOTE	REMOTE	DI	080-I-0012	
	LCP-300-01	FV	300	105	02		300-105	FV-300-105-02-CLOSE	FV-300-105-02-CLOSE	GAC ADSORBER VESSEL 1 FILTER EFFLUENT VLV CLOSE CMD	CLOSE	DO	080-I-0012	
	LCP-300-01	FV	300	105	02		300-105	FV-300-105-02-CLOSED	FV-300-105-02-CLOSED	GAC ADSORBER VESSEL 1 FILTER EFFLUENT VLV CLOSED	CLOSED	DI	080-I-0012	
	LCP-300-01	FV	300	105	02		300-105	FV-300-105-02-FAIL	FV-300-105-02-FAIL	GAC ADSORBER VESSEL 1 FILTER EFFLUENT VLV FAIL	FAIL	DI	080-I-0012	
	LCP-300-01	FV	300	105	02		300-105	FV-300-105-02-OPEN	FV-300-105-02-OPEN	GAC ADSORBER VESSEL 1 FILTER EFFLUENT VLV OPEN CMD	OPEN	DO	080-I-0012	
	LCP-300-01	FV	300	105	02		300-105	FV-300-105-02-OPENED	FV-300-105-02-OPENED	GAC ADSORBER VESSEL 1 FILTER EFFLUENT VLV OPENED	OPENED	DI	080-I-0012	
	LCP-300-01	FV	300	105	02		300-105	FV-300-105-02-REMOTE	FV-300-105-02-REMOTE	GAC ADSORBER VESSEL 1 FILTER EFFLUENT VLV REMOTE	REMOTE	DI	080-I-0012	
	LCP-300-01	FV	300	106	02		300-106	FV-300-106-02-CLOSE	FV-300-106-02-CLOSE	GAC ADSORBER VESSEL 2 FILTER EFFLUENT VLV CLOSE CMD	CLOSE	DO	080-I-0012	
	LCP-300-01	FV	300	106	02		300-106	FV-300-106-02-CLOSED	FV-300-106-02-CLOSED	GAC ADSORBER VESSEL 2 FILTER EFFLUENT VLV CLOSED	CLOSED	DI	080-I-0012	

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CS/VFD	PANEL_NO	INST TYPE	FACILITY NUMBER	LOOP	NUMBER	TAG SUFFIX	LOOP_NO	IO_TAG	TAG_NO	LOOP_TITLE	I/O FUNCTION	IO_TYPE	P+ID NO	120vac
	LCP-300-01	FV	300	106	02		300-106	FV-300-106-02-FAIL	FV-300-106-02-FAIL	GAC ADSORBER VESSEL 2 FILTER EFFLUENT VLV FAIL	FAIL	DI	080-I-0012	
	LCP-300-01	FV	300	106	02		300-106	FV-300-106-02-OPEN	FV-300-106-02-OPEN	GAC ADSORBER VESSEL 2 FILTER EFFLUENT VLV OPEN CMD	OPEN	DO	080-I-0012	
	LCP-300-01	FV	300	106	02		300-106	FV-300-106-02-OPENED	FV-300-106-02-OPENED	GAC ADSORBER VESSEL 2 FILTER EFFLUENT VLV OPENED	OPENED	DI	080-I-0012	
	LCP-300-01	FV	300	106	02		300-106	FV-300-106-02-REMOTE	FV-300-106-02-REMOTE	GAC ADSORBER VESSEL 2 FILTER EFFLUENT VLV REMOTE	REMOTE	DI	080-I-0012	
	LCP-300-01	FV	300	105	03		300-105	FV-300-105-03-CLOSE	FV-300-105-03-CLOSE	BWS TO GAC VESSEL 1 CLOSE CMD	CLOSE	DO	080-I-0012	
	LCP-300-01	FV	300	105	03		300-105	FV-300-105-03-CLOSED	FV-300-105-03-CLOSED	BWS TO GAC VESSEL 1 CLOSED	CLOSED	DI	080-I-0012	
	LCP-300-01	FV	300	105	03		300-105	FV-300-105-03-FAIL	FV-300-105-03-FAIL	BWS TO GAC VESSEL 1 FAIL	FAIL	DI	080-I-0012	
	LCP-300-01	FV	300	105	03		300-105	FV-300-105-03-OPEN	FV-300-105-03-OPEN	BWS TO GAC VESSEL 1 OPEN CMD	OPEN	DO	080-I-0012	
	LCP-300-01	FV	300	105	03		300-105	FV-300-105-03-OPENED	FV-300-105-03-OPENED	BWS TO GAC VESSEL 1 OPENED	OPENED	DI	080-I-0012	
	LCP-300-01	FV	300	105	03		300-105	FV-300-105-03-REMOTE	FV-300-105-03-REMOTE	BWS TO GAC VESSEL 1 REMOTE	REMOTE	DI	080-I-0012	
	LCP-300-01	PDS	300	105	00		300-105	PDS-300-105-00-HI D/P	PDS-300-105-00-HI D/P	GAC ADSORBER 1 DP	HI D/P	DI	080-I-0012	
	LCP-300-01	PDS	300	106	00		300-106	PDS-300-106-00-HI D/P	PDS-300-106-00-HI D/P	GAC ADSORBER 2 DP	HI D/P	DI	080-I-0012	
	LCP-300-01	FV	300	106	03		300-106	FV-300-106-03-CLOSE	FV-300-106-03-CLOSE	BWS TO GAC VESSEL 2 CLOSE CMD	CLOSE	DO	080-I-0012	
	LCP-300-01	FV	300	106	03		300-106	FV-300-106-03-CLOSED	FV-300-106-03-CLOSED	BWS TO GAC VESSEL 2 CLOSED	CLOSED	DI	080-I-0012	
	LCP-300-01	FV	300	106	03		300-106	FV-300-106-03-FAIL	FV-300-106-03-FAIL	BWS TO GAC VESSEL 2 FAIL	FAIL	DI	080-I-0012	
	LCP-300-01	FV	300	106	03		300-106	FV-300-106-03-OPEN	FV-300-106-03-OPEN	BWS TO GAC VESSEL 2 OPEN CMD	OPEN	DO	080-I-0012	
	LCP-300-01	FV	300	106	03		300-106	FV-300-106-03-OPENED	FV-300-106-03-OPENED	BWS TO GAC VESSEL 2 OPENED	OPENED	DI	080-I-0012	
	LCP-300-01	FV	300	106	03		300-106	FV-300-106-03-REMOTE	FV-300-106-03-REMOTE	BWS TO GAC VESSEL 2 REMOTE	REMOTE	DI	080-I-0012	
	LCP-300-01	LIT	360	101	01		360-101	LIT-360-101-01-LEVEL	LIT-360-101-01-LEVEL	DOMESTIC WATER WELL LEVEL	LEVEL	AI	080-I-0013	120vac

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CS/VFD	PANEL_NO	INST TYPE	FACILITY NUMBER	LOOP	NUMBER	TAG SUFFIX	LOOP_NO	IO_TAG	TAG_NO	LOOP_TITLE	I/O FUNCTION	IO_TYPE	P+ID NO	120vac
VFD	LCP-300-01	PMP	360	101	01		360-101	PMP-360-101-01-FAIL	PMP-360-101-01-FAIL	DOMESTIC WATER SUPPLY PUMP 1 FAIL	FAIL	ET	080-I-0013	
VFD	LCP-300-01	PMP	360	101	01		360-101	PMP-360-101-01-REMOTE	PMP-360-101-01-REMOTE	DOMESTIC WATER SUPPLY PUMP 1 IN REMOTE	REMOTE	ET	080-I-0013	
VFD	LCP-300-01	PMP	360	101	01		360-101	PMP-360-101-01-RUNNING	PMP-360-101-01-RUNNING	DOMESTIC WATER SUPPLY PUMP 1 RUNNING	RUNNING	ET	080-I-0013	
VFD	LCP-300-01	PMP	360	101	01		360-101	PMP-360-101-01-SC	PMP-360-101-01-SC	DOMESTIC WATER SUPPLY PUMP 1 SPD CMD	SC	ET	080-I-0013	
VFD	LCP-300-01	PMP	360	101	01		360-101	PMP-360-101-01-SI	PMP-360-101-01-SI	DOMESTIC WATER SUPPLY PUMP 1 SPD IND	SI	ET	080-I-0013	
VFD	LCP-300-01	PMP	360	101	01		360-101	PMP-360-101-01-START	PMP-360-101-01-START	DOMESTIC WATER SUPPLY PUMP 1 START	START	ET	080-I-0013	
VFD	LCP-300-01	PMP	360	101	02		360-101	PMP-360-101-02-FAIL	PMP-360-101-02-FAIL	DOMESTIC WATER SUPPLY PUMP 2 FAIL	FAIL	ET	080-I-0013	
VFD	LCP-300-01	PMP	360	101	02		360-101	PMP-360-101-02-REMOTE	PMP-360-101-02-REMOTE	DOMESTIC WATER SUPPLY PUMP 2 IN REMOTE	REMOTE	ET	080-I-0013	
VFD	LCP-300-01	PMP	360	101	02		360-101	PMP-360-101-02-RUNNING	PMP-360-101-02-RUNNING	DOMESTIC WATER SUPPLY PUMP 2 RUNNING	RUNNING	ET	080-I-0013	
VFD	LCP-300-01	PMP	360	101	02		360-101	PMP-360-101-02-SC	PMP-360-101-02-SC	DOMESTIC WATER SUPPLY PUMP 2 SPD CMD	SC	ET	080-I-0013	
VFD	LCP-300-01	PMP	360	101	02		360-101	PMP-360-101-02-SI	PMP-360-101-02-SI	DOMESTIC WATER SUPPLY PUMP 2 SPD IND	SI	ET	080-I-0013	
VFD	LCP-300-01	PMP	360	101	02		360-101	PMP-360-101-02-START	PMP-360-101-02-START	DOMESTIC WATER SUPPLY PUMP 2 START	START	ET	080-I-0013	
	LCP-300-01	LIT	500	101	01		500-101	LIT-500-101-01-LEVEL	LIT-500-101-01-LEVEL	FIRE WATER WELL LEVEL	LEVEL	AI	080-I-0013	120vac
	LCP-300-01	PMP	500	102	01		500-102	PMP-500-102-01-FAIL	PMP-500-102-01-FAIL	FIRE SUPPRESSION PUMP FAIL	FAIL	DI	080-I-0013	
	LCP-300-01	PMP	500	102	01		500-102	PMP-500-102-01-LOW DEISEL	PMP-500-102-01-LOW DEISEL	FIRE SUPPRESSION PUMP	LOW DEISEL	DI	080-I-0013	
	LCP-300-01	PMP	500	102	01		500-102	PMP-500-102-01-RUNNING	PMP-500-102-01-RUNNING	FIRE SUPPRESSION PUMP RUNNING	RUNNING	DI	080-I-0013	
	LCP-300-01	PMP	360	103	01		360-103	PMP-360-103-01-RUNNING	PMP-360-103-01-RUNNING	DOMESTIC WATER SAMPLE PUMP RUNNING	RUNNING	DI	080-I-0013	
	LCP-300-01	GTE	360	108	01		360-108	GTE-360-108-01-OPEN	GTE-360-108-01-OPEN	WET WELL ISOLATION GATE 1	OPEN	DO	080-I-0013	
	LCP-300-01	GTE	360	108	01		360-108	GTE-360-108-01-CLOSE	GTE-360-108-01-CLOSE	WET WELL ISOLATION GATE 1	CLOSE	DO	080-I-0013	
	LCP-300-01	GTE	360	108	01		360-108	GTE-360-108-01-OPENED	GTE-360-108-01-OPENED	WET WELL ISOLATION GATE 1	OPENED	DI	080-I-0013	
	LCP-300-01	GTE	360	108	01		360-108	GTE-360-108-01-CLOSED	GTE-360-108-01-CLOSED	WET WELL ISOLATION GATE 1	CLOSED	DI	080-I-0013	

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CS/VFD	PANEL_NO	INST TYPE	FACILITY NUMBER	LOOP	NUMBER	TAG SUFFIX	LOOP_NO	IO_TAG	TAG_NO	LOOP_TITLE	I/O FUNCTION	IO_TYPE	P+ID NO	120vac
	LCP-300-01	GTE	360	108	01		360-108	GTE-360-108-01-REMOTE	GTE-360-108-01-REMOTE	WET WELL ISOLATION GATE 1	REMOTE	DI	080-I-0013	
	LCP-300-01	GTE	360	108	01		360-108	GTE-360-108-01-FAIL	GTE-360-108-01-FAIL	WET WELL ISOLATION GATE 1	FAIL	DI	080-I-0013	
	LCP-300-01	GTE	360	108	02		360-108	GTE-360-108-02-OPEN	GTE-360-108-02-OPEN	WET WELL ISOLATION GATE 2	OPEN	DO	080-I-0013	
	LCP-300-01	GTE	360	108	02		360-108	GTE-360-108-02-CLOSE	GTE-360-108-02-CLOSE	WET WELL ISOLATION GATE 2	CLOSE	DO	080-I-0013	
	LCP-300-01	GTE	360	108	02		360-108	GTE-360-108-02-OPENED	GTE-360-108-02-OPENED	WET WELL ISOLATION GATE 2	OPENED	DI	080-I-0013	
	LCP-300-01	GTE	360	108	02		360-108	GTE-360-108-02-CLOSED	GTE-360-108-02-CLOSED	WET WELL ISOLATION GATE 2	CLOSED	DI	080-I-0013	
	LCP-300-01	GTE	360	108	02		360-108	GTE-360-108-02-REMOTE	GTE-360-108-02-REMOTE	WET WELL ISOLATION GATE 2	REMOTE	DI	080-I-0013	
	LCP-300-01	GTE	360	108	02		360-108	GTE-360-108-02-FAIL	GTE-360-108-02-FAIL	WET WELL ISOLATION GATE 2	FAIL	DI	080-I-0013	
	LCP-300-01	GTE	360	108	03		360-108	GTE-360-108-03-OPEN	GTE-360-108-03-OPEN	WET WELL ISOLATION GATE 3	OPEN	DO	080-I-0013	
	LCP-300-01	GTE	360	108	03		360-108	GTE-360-108-03-CLOSE	GTE-360-108-03-CLOSE	WET WELL ISOLATION GATE 3	CLOSE	DO	080-I-0013	
	LCP-300-01	GTE	360	108	03		360-108	GTE-360-108-03-OPENED	GTE-360-108-03-OPENED	WET WELL ISOLATION GATE 3	OPENED	DI	080-I-0013	
	LCP-300-01	GTE	360	108	03		360-108	GTE-360-108-03-CLOSED	GTE-360-108-03-CLOSED	WET WELL ISOLATION GATE 3	CLOSED	DI	080-I-0013	
	LCP-300-01	GTE	360	108	03		360-108	GTE-360-108-03-REMOTE	GTE-360-108-03-REMOTE	WET WELL ISOLATION GATE 3	REMOTE	DI	080-I-0013	
	LCP-300-01	GTE	360	108	03		360-108	GTE-360-108-03-FAIL	GTE-360-108-03-FAIL	WET WELL ISOLATION GATE 3	FAIL	DI	080-I-0013	
	LCP-300-01	GTE	360	108	04		360-108	GTE-360-108-04-OPEN	GTE-360-108-04-OPEN	WET WELL ISOLATION GATE 4	OPEN	DO	080-I-0013	
	LCP-300-01	GTE	360	108	04		360-108	GTE-360-108-04-CLOSE	GTE-360-108-04-CLOSE	WET WELL ISOLATION GATE 4	CLOSE	DO	080-I-0013	
	LCP-300-01	GTE	360	108	04		360-108	GTE-360-108-04-OPENED	GTE-360-108-04-OPENED	WET WELL ISOLATION GATE 4	OPENED	DI	080-I-0013	
	LCP-300-01	GTE	360	108	04		360-108	GTE-360-108-04-CLOSED	GTE-360-108-04-CLOSED	WET WELL ISOLATION GATE 4	CLOSED	DI	080-I-0013	
	LCP-300-01	GTE	360	108	04		360-108	GTE-360-108-04-REMOTE	GTE-360-108-04-REMOTE	WET WELL ISOLATION GATE 4	REMOTE	DI	080-I-0013	
	LCP-300-01	GTE	360	108	04		360-108	GTE-360-108-04-FAIL	GTE-360-108-04-FAIL	WET WELL ISOLATION GATE 4	FAIL	DI	080-I-0013	
	LCP-300-01	GTE	360	108	05		360-108	GTE-360-108-05-OPEN	GTE-360-108-05-OPEN	WET WELL ISOLATION GATE 5	OPEN	DO	080-I-0013	

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CS/VFD	PANEL_NO	INST TYPE	FACILITY NUMBER	LOOP	NUMBER	TAG SUFFIX	LOOP_NO	IO_TAG	TAG_NO	LOOP_TITLE	I/O FUNCTION	IO_TYPE	P+ID NO	120vac
	LCP-300-01	GTE	360	108	05		360-108	GTE-360-108-05-CLOSE	GTE-360-108-05-CLOSE	WET WELL ISOLATION GATE 5	CLOSE	DO	080-I-0013	
	LCP-300-01	GTE	360	108	05		360-108	GTE-360-108-05-OPENED	GTE-360-108-05-OPENED	WET WELL ISOLATION GATE 1	OPENED	DI	080-I-0013	
	LCP-300-01	GTE	360	108	05		360-108	GTE-360-108-05-CLOSED	GTE-360-108-05-CLOSED	WET WELL ISOLATION GATE 1	CLOSED	DI	080-I-0013	
	LCP-300-01	GTE	360	108	05		360-108	GTE-360-108-05-REMOTE	GTE-360-108-05-REMOTE	Wet Well Isolation Gate 5	REMOTE	DI	080-I-0013	
	LCP-300-01	GTE	360	108	05		360-108	GTE-360-108-05-FAIL	GTE-360-108-05-FAIL	WET WELL ISOLATION GATE 1	FAIL	DI	080-I-0013	
	LCP-300-01	GTE	360	108	06		360-108	GTE-360-108-06-OPEN	GTE-360-108-06-OPEN	WET WELL ISOLATION GATE 6	OPEN	DO	080-I-0013	
	LCP-300-01	GTE	360	108	06		360-108	GTE-360-108-06-CLOSE	GTE-360-108-06-CLOSE	WET WELL ISOLATION GATE 6	CLOSE	DO	080-I-0013	
	LCP-300-01	GTE	360	108	06		360-108	GTE-360-108-06-OPENED	GTE-360-108-06-OPENED	WET WELL ISOLATION GATE 1	OPENED	DI	080-I-0013	
	LCP-300-01	GTE	360	108	06		360-108	GTE-360-108-06-CLOSED	GTE-360-108-06-CLOSED	WET WELL ISOLATION GATE 1	CLOSED	DI	080-I-0013	
	LCP-300-01	GTE	360	108	06		360-108	GTE-360-108-06-REMOTE	GTE-360-108-06-REMOTE	Wet Well Isolation Gate 6	REMOTE	DI	080-I-0013	
	LCP-300-01	GTE	360	108	06		360-108	GTE-360-108-06-FAIL	GTE-360-108-06-FAIL	WET WELL ISOLATION GATE 1	FAIL	DI	080-I-0013	
	LCP-300-01	AIT	360	101	03	A	360-101	AIT-360-101-03A-PH	AIT-360-101-03A-PH	FINSIHED WATER PH	PH	AI	080-I-0013	120vac
	LCP-300-01	AIT	360	101	03	B	360-101	AIT-360-101-03B-CL2	AIT-360-101-03B-CL2	FINISHED WATER TURBIDITY	CL2	AI	080-I-0013	120vac
	LCP-300-01	PIT	300	102	3		300-102	PIT-300-102-3-PRESS	PIT-300-102-3-PRESS	DOMESTIC WATER PUMPS COMBINED DISCHARGE	PRESS	AI	080-I-0013	
VFD	LCP-300-01	PMP	360	104	01		360-104	PMP-360-104-01-FAIL	PMP-360-104-01-FAIL	FINISHED WATER PUMP 1 FAIL	FAIL	ET	080-I-0014	
VFD	LCP-300-01	PMP	360	104	01		360-104	PMP-360-104-01-REMOTE	PMP-360-104-01-REMOTE	FINISHED WATER PUMP 1 IN REMOTE	REMOTE	ET	080-I-0014	
VFD	LCP-300-01	PMP	360	104	01		360-104	PMP-360-104-01-RUNNING	PMP-360-104-01-RUNNING	FINISHED WATER PUMP 1 RUNNING	RUNNING	ET	080-I-0014	
VFD	LCP-300-01	PMP	360	104	01		360-104	PMP-360-104-01-SC	PMP-360-104-01-SC	FINISHED WATER PUMP 1 SPD CMD	SC	ET	080-I-0014	
VFD	LCP-300-01	PMP	360	104	01		360-104	PMP-360-104-01-SI	PMP-360-104-01-SI	FINISHED WATER PUMP 1 SPD IND	SI	ET	080-I-0014	
VFD	LCP-300-01	PMP	360	104	01		360-104	PMP-360-104-01-START	PMP-360-104-01-START	FINISHED WATER PUMP 1 START	START	ET	080-I-0014	
	LCP-300-01	FV	360	104	01		360-104	FV-360-104-01-CLOSE	FV-360-104-01-CLOSE	FINISHED WATER PUMP 1 DISCHG VLV CLOSE CMD	CLOSE	DO	080-I-0014	

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CS/VFD	PANEL_NO	INST TYPE	FACILITY NUMBER	LOOP	NUMBER	TAG SUFFIX	LOOP_NO	IO_TAG	TAG_NO	LOOP_TITLE	I/O FUNCTION	IO_TYPE	P+ID NO	120vac
	LCP-300-01	FV	360	104	01		360-104	FV-360-104-01-CLOSED	FV-360-104-01-CLOSED	FINISHED WATER PUMP 1 DISCHG VALVE CLOSED	CLOSED	DI	080-I-0014	
	LCP-300-01	FV	360	104	01		360-104	FV-360-104-01-FAIL	FV-360-104-01-FAIL	FINISHED WATER PUMP 1 DISCHG VALVE FAIL	FAIL	DI	080-I-0014	
	LCP-300-01	FV	360	104	01		360-104	FV-360-104-01-OPEN	FV-360-104-01-OPEN	FINISHED WATER PUMP 1 DISCHG VLV OPEN CMD	OPEN	DO	080-I-0014	
	LCP-300-01	FV	360	104	01		360-104	FV-360-104-01-OPENED	FV-360-104-01-OPENED	FINISHED WATER PUMP 1 DISCHG VALVE OPENED	OPENED	DI	080-I-0014	
	LCP-300-01	FV	360	104	01		360-104	FV-360-104-01-REMOTE	FV-360-104-01-REMOTE	FINISHED WATER PUMP 1 DISCHG VALVE IN REMOTE	REMOTE	DI	080-I-0014	
VFD	LCP-300-01	PMP	360	104	03		360-104	PMP-360-104-03-FAIL	PMP-360-104-03-FAIL	FINISHED WATER PUMP 2 FAIL	FAIL	ET	080-I-0014	
VFD	LCP-300-01	PMP	360	104	03		360-104	PMP-360-104-03-REMOTE	PMP-360-104-03-REMOTE	FINISHED WATER PUMP 2 IN REMOTE	REMOTE	ET	080-I-0014	
VFD	LCP-300-01	PMP	360	104	03		360-104	PMP-360-104-03-RUNNING	PMP-360-104-03-RUNNING	FINISHED WATER PUMP 2 RUNNING	RUNNING	ET	080-I-0014	
VFD	LCP-300-01	PMP	360	104	03		360-104	PMP-360-104-03-SC	PMP-360-104-03-SC	FINISHED WATER PUMP 2 SPD CMD	SC	ET	080-I-0014	
VFD	LCP-300-01	PMP	360	104	03		360-104	PMP-360-104-03-SI	PMP-360-104-03-SI	FINISHED WATER PUMP 2 SPD IND	SI	ET	080-I-0014	
VFD	LCP-300-01	PMP	360	104	03		360-104	PMP-360-104-03-START	PMP-360-104-03-START	FINISHED WATER PUMP 2 START	START	ET	080-I-0014	
	LCP-300-01	FV	360	104	02		360-104	FV-360-104-02-CLOSE	FV-360-104-02-CLOSE	FINISHED WATER PUMP 2 DISCHG VLV CLOSE CMD	CLOSE	DO	080-I-0014	
	LCP-300-01	FV	360	104	02		360-104	FV-360-104-02-CLOSED	FV-360-104-02-CLOSED	FINISHED WATER PUMP 2 DISCHG VALVE CLOSED	CLOSED	DI	080-I-0014	
	LCP-300-01	FV	360	104	02		360-104	FV-360-104-02-FAIL	FV-360-104-02-FAIL	FINISHED WATER PUMP 2 DISCHG VALVE FAIL	FAIL	DI	080-I-0014	
	LCP-300-01	FV	360	104	02		360-104	FV-360-104-02-OPEN	FV-360-104-02-OPEN	FINISHED WATER PUMP 2 DISCHG VLV OPEN CMD	OPEN	DO	080-I-0014	
	LCP-300-01	FV	360	104	02		360-104	FV-360-104-02-OPENED	FV-360-104-02-OPENED	FINISHED WATER PUMP 2 DISCHG VALVE OPENED	OPENED	DI	080-I-0014	
	LCP-300-01	FV	360	104	02		360-104	FV-360-104-02-REMOTE	FV-360-104-02-REMOTE	FINISHED WATER PUMP 2 DISCHG VALVE IN REMOTE	REMOTE	DI	080-I-0014	
VFD	LCP-300-01	PMP	360	105	01		360-105	PMP-360-105-01-FAIL	PMP-360-105-01-FAIL	BACKWASH SUPPLY PUMP 1 FAIL	FAIL	ET	080-I-0014	
VFD	LCP-300-01	PMP	360	105	01		360-105	PMP-360-105-01-REMOTE	PMP-360-105-01-REMOTE	BACKWASH SUPPLY PUMP 1 IN REMOTE	REMOTE	ET	080-I-0014	
VFD	LCP-300-01	PMP	360	105	01		360-105	PMP-360-105-01-RUNNING	PMP-360-105-01-RUNNING	BACKWASH SUPPLY PUMP 1 RUNNING	RUNNING	ET	080-I-0014	
VFD	LCP-300-01	PMP	360	105	01		360-105	PMP-360-105-01-SC	PMP-360-105-01-SC	BACKWASH SUPPLY PUMP 1 SPD CMD	SC	ET	080-I-0014	

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CS/VFD	PANEL_NO	INST TYPE	FACILITY NUMBER	LOOP	NUMBER	TAG SUFFIX	LOOP_NO	IO_TAG	TAG_NO	LOOP_TITLE	I/O FUNCTION	IO_TYPE	P+ID NO	120vac
VFD	LCP-300-01	PMP	360	105	01		360-105	PMP-360-105-01-SI	PMP-360-105-01-SI	BACKWASH SUPPLY PUMP 1 SPD IND	SI	ET	080-I-0014	
VFD	LCP-300-01	PMP	360	105	01		360-105	PMP-360-105-01-START	PMP-360-105-01-START	BACKWASH SUPPLY PUMP 1 START	START	ET	080-I-0014	
	LCP-300-01	FV	360	105	02		360-105	FV-360-105-02-CLOSE	FV-360-105-02-CLOSE	BACKWASH SUPPLY PUMP 1 DISCHG VLV CLOSE CMD	CLOSE	DO	080-I-0014	
	LCP-300-01	FV	360	105	02		360-105	FV-360-105-02-CLOSED	FV-360-105-02-CLOSED	BACKWASH SUPPLY PUMP 1 DISCHG VALVE CLOSED	CLOSED	DI	080-I-0014	
	LCP-300-01	FV	360	105	02		360-105	FV-360-105-02-FAIL	FV-360-105-02-FAIL	BACKWASH SUPPLY PUMP 1 DISCHG VALVE FAIL	FAIL	DI	080-I-0014	
	LCP-300-01	FV	360	105	02		360-105	FV-360-105-02-OPEN	FV-360-105-02-OPEN	BACKWASH SUPPLY PUMP 1 DISCHG VLV OPEN CMD	OPEN	DO	080-I-0014	
	LCP-300-01	FV	360	105	02		360-105	FV-360-105-02-OPENED	FV-360-105-02-OPENED	BACKWASH SUPPLY PUMP 1 DISCHG VALVE OPENED	OPENED	DI	080-I-0014	
	LCP-300-01	FV	360	105	02		360-105	FV-360-105-02-REMOTE	FV-360-105-02-REMOTE	BACKWASH SUPPLY PUMP 1 DISCHG VALVE IN REMOTE	REMOTE	DI	080-I-0014	
	LCP-300-01	LIT	360	106	01		360-106	LIT-360-106-01-LEVEL	LIT-360-106-01-LEVEL	FINISHED WATER WELL #1 LEVEL	LEVEL	AI	080-I-0014	120vac
VFD	LCP-300-01	PMP	360	204	01		360-204	PMP-360-204-01-FAIL	PMP-360-204-01-FAIL	FINISHED WATER PUMP 3 FAIL	FAIL	ET	080-I-0014	
VFD	LCP-300-01	PMP	360	204	01		360-204	PMP-360-204-01-REMOTE	PMP-360-204-01-REMOTE	FINISHED WATER PUMP 3 IN REMOTE	REMOTE	ET	080-I-0014	
VFD	LCP-300-01	PMP	360	204	01		360-204	PMP-360-204-01-RUNNING	PMP-360-204-01-RUNNING	FINISHED WATER PUMP 3 RUNNING	RUNNING	ET	080-I-0014	
VFD	LCP-300-01	PMP	360	204	01		360-204	PMP-360-204-01-SC	PMP-360-204-01-SC	FINISHED WATER PUMP 3 SPD CMD	SC	ET	080-I-0014	
VFD	LCP-300-01	PMP	360	204	01		360-204	PMP-360-204-01-SI	PMP-360-204-01-SI	FINISHED WATER PUMP 3 SPD IND	SI	ET	080-I-0014	
VFD	LCP-300-01	PMP	360	204	01		360-204	PMP-360-204-01-START	PMP-360-204-01-START	FINISHED WATER PUMP 3 START	START	ET	080-I-0014	
	LCP-300-01	FV	360	104	03		360-104	FV-360-104-03-CLOSED	FV-360-104-03-CLOSED	FINISHED WATER PUMP 3 DISCHG VALVE CLOSED	CLOSED	DI	080-I-0014	
	LCP-300-01	FV	360	104	03		360-104	FV-360-104-03-FAIL	FV-360-104-03-FAIL	FINISHED WATER PUMP 3 DISCHG VALVE FAIL	FAIL	DI	080-I-0014	
	LCP-300-01	FV	360	104	03		360-104	FV-360-104-03-OPENED	FV-360-104-03-OPENED	FINISHED WATER PUMP 3 DISCHG VALVE OPENED	OPENED	DI	080-I-0014	
	LCP-300-01	FV	360	104	03		360-104	FV-360-104-03-REMOTE	FV-360-104-03-REMOTE	FINISHED WATER PUMP 3 DISCHG VALVE IN REMOTE	REMOTE	DI	080-I-0014	
	LCP-300-01	FV	360	104	03		360-104	FV-360-104-03-CLOSE	FV-360-104-03-CLOSE	FINISHED WATER PUMP 3 DISCHG VLV CLOSE CMD	CLOSE	DO	080-I-0014	
	LCP-300-01	FV	360	104	03		360-104	FV-360-104-03-OPEN	FV-360-104-03-OPEN	FINISHED WATER PUMP 3 DISCHG VLV OPEN CMD	OPEN	DO	080-I-0014	

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CS/VFD	PANEL_NO	INST TYPE	FACILITY NUMBER	LOOP	NUMBER	TAG SUFFIX	LOOP_NO	IO_TAG	TAG_NO	LOOP_TITLE	I/O FUNCTION	IO_TYPE	P+ID NO	120vac
VFD	LCP-300-01	PMP	360	204	03		360-204	PMP-360-204-03-FAIL	PMP-360-204-03-FAIL	FINISHED WATER PUMP 4 FAIL	FAIL	ET	080-I-0014	
VFD	LCP-300-01	PMP	360	204	03		360-204	PMP-360-204-03-REMOTE	PMP-360-204-03-REMOTE	FINISHED WATER PUMP 4 IN REMOTE	REMOTE	ET	080-I-0014	
VFD	LCP-300-01	PMP	360	204	03		360-204	PMP-360-204-03-RUNNING	PMP-360-204-03-RUNNING	FINISHED WATER PUMP 4 RUNNING	RUNNING	ET	080-I-0014	
VFD	LCP-300-01	PMP	360	204	03		360-204	PMP-360-204-03-SC	PMP-360-204-03-SC	FINISHED WATER PUMP 4 SPD CMD	SC	ET	080-I-0014	
VFD	LCP-300-01	PMP	360	204	03		360-204	PMP-360-204-03-SI	PMP-360-204-03-SI	FINISHED WATER PUMP 4 SPD IND	SI	ET	080-I-0014	
VFD	LCP-300-01	PMP	360	204	03		360-204	PMP-360-204-03-START	PMP-360-204-03-START	FINISHED WATER PUMP 4 START	START	ET	080-I-0014	
	LCP-300-01	FV	360	104	04		360-104	FV-360-104-04-CLOSE	FV-360-104-04-CLOSE	FINISHED WATER PUMP 4 DISCHG VLV CLOSE CMD	CLOSE	DO	080-I-0014	
	LCP-300-01	FV	360	104	04		360-104	FV-360-104-04-CLOSED	FV-360-104-04-CLOSED	FINISHED WATER PUMP 4 DISCHG VALVE CLOSED	CLOSED	DI	080-I-0014	
	LCP-300-01	FV	360	104	04		360-104	FV-360-104-04-FAIL	FV-360-104-04-FAIL	FINISHED WATER PUMP 4 DISCHG VALVE FAIL	FAIL	DI	080-I-0014	
	LCP-300-01	FV	360	104	04		360-104	FV-360-104-04-OPEN	FV-360-104-04-OPEN	FINISHED WATER PUMP 4 DISCHG VLV OPEN CMD	OPEN	DO	080-I-0014	
	LCP-300-01	FV	360	104	04		360-104	FV-360-104-04-OPENED	FV-360-104-04-OPENED	FINISHED WATER PUMP 4 DISCHG VALVE OPENED	OPENED	DI	080-I-0014	
	LCP-300-01	FV	360	104	04		360-104	FV-360-104-04-REMOTE	FV-360-104-04-REMOTE	FINISHED WATER PUMP 4 DISCHG VALVE IN REMOTE	REMOTE	DI	080-I-0014	
VFD	LCP-300-01	PMP	360	205	01		360-205	PMP-360-205-01-FAIL	PMP-360-205-01-FAIL	BACKWASH SUPPLY PUMP 2 FAIL	FAIL	ET	080-I-0014	
VFD	LCP-300-01	PMP	360	205	01		360-205	PMP-360-205-01-REMOTE	PMP-360-205-01-REMOTE	BACKWASH SUPPLY PUMP 2 IN REMOTE	REMOTE	ET	080-I-0014	
VFD	LCP-300-01	PMP	360	205	01		360-205	PMP-360-205-01-RUNNING	PMP-360-205-01-RUNNING	BACKWASH SUPPLY PUMP 2 RUNNING	RUNNING	ET	080-I-0014	
VFD	LCP-300-01	PMP	360	205	01		360-205	PMP-360-205-01-SC	PMP-360-205-01-SC	BACKWASH SUPPLY PUMP 2 SPD CMD	SC	ET	080-I-0014	
VFD	LCP-300-01	PMP	360	205	01		360-205	PMP-360-205-01-SI	PMP-360-205-01-SI	BACKWASH SUPPLY PUMP 2 SPD IND	SI	ET	080-I-0014	
VFD	LCP-300-01	PMP	360	205	01		360-205	PMP-360-205-01-START	PMP-360-205-01-START	BACKWASH SUPPLY PUMP 2 START	START	ET	080-I-0014	
	LCP-300-01	FV	360	205	02		360-205	FV-360-205-02-CLOSE	FV-360-205-02-CLOSE	BACKWASH SUPPLY PUMP 2 DISCHG VLV CLOSE CMD	CLOSE	DO	080-I-0014	
	LCP-300-01	FV	360	205	02		360-205	FV-360-205-02-CLOSED	FV-360-205-02-CLOSED	BACKWASH SUPPLY PUMP 2 DISCHG VALVE CLOSED	CLOSED	DI	080-I-0014	
	LCP-300-01	FV	360	205	02		360-205	FV-360-205-02-FAIL	FV-360-205-02-FAIL	BACKWASH SUPPLY PUMP 2 DISCHG VALVE FAIL	FAIL	DI	080-I-0014	

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CS/VFD	PANEL_NO	INST TYPE	FACILITY NUMBER	LOOP	NUMBER	TAG SUFFIX	LOOP_NO	IO_TAG	TAG_NO	LOOP_TITLE	I/O FUNCTION	IO_TYPE	P+ID NO	120vac
	LCP-300-01	FV	360	205	02		360-205	FV-360-205-02-OPEN	FV-360-205-02-OPEN	BACKWASH SUPPLY PUMP 2 DISCHG VLV OPEN CMD	OPEN	DO	080-I-0014	
	LCP-300-01	FV	360	205	02		360-205	FV-360-205-02-OPENED	FV-360-205-02-OPENED	BACKWASH SUPPLY PUMP 2 DISCHG VALVE OPENED	OPENED	DI	080-I-0014	
	LCP-300-01	FV	360	205	02		360-205	FV-360-205-02-REMOTE	FV-360-205-02-REMOTE	BACKWASH SUPPLY PUMP 2 DISCHG VALVE IN REMOTE	REMOTE	DI	080-I-0014	
	LCP-300-01	LIT	360	206	01		360-206	LIT-360-206-01-LEVEL	LIT-360-206-01-LEVEL	FINISHED WATER WELL #2 LEVEL	LEVEL	AI	080-I-0014	120vac
	LCP-300-01	FIT	360	304	01		360-304	FIT-360-304-01-FAIL	FIT-360-304-01-FAIL	FINISHED WATER FLOW TO TANK 3 FAIL	FAIL	DI	080-I-0014	
	LCP-300-01	FIT	360	304	01		360-304	FIT-360-304-01-FLOW	FIT-360-304-01-FLOW	FINISHED WATER FLOW TO TANK 3 FLOW	FLOW	AI	080-I-0014	120vac
	LCP-300-01	FIT	360	304	01		360-304	FIT-360-304-01-PULSE	FIT-360-304-01-PULSE	FINISHED WATER FLOW TO TANK 3 PULSE	PULSE	DI	080-I-0014	
	LCP-300-01	FCV	360	304	04		360-304	FCV-360-304-04-REMOTE	FCV-360-304-04-REMOTE	FINISHED WATER TO FINISHED WATER STILLING BASIN IN REMOTE	REMOTE	DI	080-I-0014	
	LCP-300-01	FCV	360	304	04		360-304	FCV-360-304-04-ZC	FCV-360-304-04-ZC	FINISHED WATER TO FINISHED WATER STILLING BASIN POS CMD	ZC	AO	080-I-0014	
	LCP-300-01	FCV	360	304	04		360-304	FCV-360-304-04-ZT	FCV-360-304-04-ZT	FINISHED WATER TO FINISHED WATER STILLING BASIN POS IND	ZT	AI	080-I-0014	
	LCP-300-01	FIT	360	304	04		360-304	FIT-360-304-04-FAIL	FIT-360-304-04-FAIL	FINISHED WATER TO FINISHED WATER STILLING BASIN FAIL	FAIL	DI	080-I-0014	
	LCP-300-01	FIT	360	305	01		360-305	FIT-360-305-01-FAIL	FIT-360-305-01-FAIL	BACKWASH FLOW TO FILTERS FAIL	FAIL	DI	080-I-0014	
	LCP-300-01	FIT	360	305	01		360-305	FIT-360-305-01-FLOW	FIT-360-305-01-FLOW	BACKWASH FLOW TO FILTERS FLOW	FLOW	AI	080-I-0014	120vac
	LCP-300-01	FIT	360	305	01		360-305	FIT-360-305-01-PULSE	FIT-360-305-01-PULSE	BACKWASH FLOW TO FILTERS PULSE	PULSE	DI	080-I-0014	
	LCP-300-01	FV	360	305	02		360-305	FV-360-305-02-CLOSE	FV-360-305-02-CLOSE	BACKWASH TO FILTERS/GAC DISCHG VALVE CLOSE CMD	CLOSE	DO	080-I-0014	
	LCP-300-01	FV	360	305	02		360-305	FV-360-305-02-CLOSED	FV-360-305-02-CLOSED	BACKWASH TO FILTERS/GAC DISCHG VALVE CLOSED	CLOSED	DI	080-I-0014	
	LCP-300-01	FV	360	305	02		360-305	FV-360-305-02-FAIL	FV-360-305-02-FAIL	BACKWASH TO FILTERS/GAC DISCHG VALVE FAIL	FAIL	DI	080-I-0014	
	LCP-300-01	FV	360	305	02		360-305	FV-360-305-02-OPEN	FV-360-305-02-OPEN	BACKWASH TO FILTERS/GAC DISCHG VALVE OPEN CMD	OPEN	DO	080-I-0014	
	LCP-300-01	FV	360	305	02		360-305	FV-360-305-02-OPENED	FV-360-305-02-OPENED	BACKWASH TO FILTERS/GAC DISCHG VALVE OPENED	OPENED	DI	080-I-0014	

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CS/VFD	PANEL_NO	INST TYPE	FACILITY NUMBER	LOOP	NUMBER	TAG SUFFIX	LOOP_NO	IO_TAG	TAG_NO	LOOP_TITLE	I/O FUNCTION	IO_TYPE	P+ID NO	120vac
	LCP-300-01	FV	360	305	02		360-305	FV-360-305-02-REMOTE	FV-360-305-02-REMOTE	BACKWASH TO FILTERS/GAC DISCHG VALVE REMOTE	REMOTE	DI	080-I-0014	
	LCP-300-01	FV	360	305	03		360-305	FV-360-305-03-CLOSE	FV-360-305-03-CLOSE	BACKWASH COMBINED DISCHARGE TO PLANT INFLUENT VALVE CLOSE CMD	CLOSE	DO	080-I-0014	
	LCP-300-01	FV	360	305	03		360-305	FV-360-305-03-CLOSED	FV-360-305-03-CLOSED	BACKWASH COMBINED DISCHARGE TO PLANT INFLUENT VALVE CLOSED	CLOSED	DI	080-I-0014	
	LCP-300-01	FV	360	305	03		360-305	FV-360-305-03-FAIL	FV-360-305-03-FAIL	BACKWASH COMBINED DISCHARGE TO PLANT INFLUENT VALVE FAIL	FAIL	DI	080-I-0014	
	LCP-300-01	FV	360	305	03		360-305	FV-360-305-03-OPEN	FV-360-305-03-OPEN	BACKWASH COMBINED DISCHARGE TO PLANT INFLUENT VALVE OPEN CMD	OPEN	DO	080-I-0014	
	LCP-300-01	FV	360	305	03		360-305	FV-360-305-03-OPENED	FV-360-305-03-OPENED	BACKWASH COMBINED DISCHARGE TO PLANT INFLUENT VALVE OPENED	OPENED	DI	080-I-0014	
	LCP-300-01	FV	360	305	03		360-305	FV-360-305-03-REMOTE	FV-360-305-03-REMOTE	BACKWASH COMBINED DISCHARGE TO PLANT INFLUENT VALVE REMOTE	REMOTE	DI	080-I-0014	
	LCP-300-01	AIT	360	304	01		360-304	AIT-360-304-01-PH	AIT-360-304-01-PH	FINISHED WATER TO TANK 3 PH	PH	AI	080-I-0014	120vac
	LCP-300-01	PIT	360	304	03		360-304	PIT-360-304-03-PRESS	PIT-360-304-03-PRESS	FINISHED WATER TO TANK 3 PRESS	PRESS	AI	080-I-0013	
	LCP-300-01	PDIT	360	108	02		360-108	PDIT-360-108-02-D/P	PDIT-360-108-02-D/P	SURGE TANK D/P	D/P	AI	080-I-0015	
	LCP-380-01	LIT	420	100	01		420-100	LIT-420-100-01-LEVEL	LIT-420-100-01-LEVEL	BWW POND INFLUENT BOX LEVEL	LEVEL	AI	080-I-0016	120vac
	LCP-380-01	GTE	420	101	01		420-101	GTE-420-101-01-CLOSE	GTE-420-101-01-CLOSE	BWW SPEC POND 1 OUTLET GATE CLOSE CMD	CLOSE	DO	080-I-0016	
	LCP-380-01	GTE	420	101	01		420-101	GTE-420-101-01-CLOSED	GTE-420-101-01-CLOSED	BWW SPEC POND 1 OUTLET GATE CLOSED	CLOSED	DI	080-I-0016	
	LCP-380-01	GTE	420	101	01		420-101	GTE-420-101-01-OPEN	GTE-420-101-01-OPEN	BWW SPEC POND 1 OUTLET GATE OPEN CMD	OPEN	DO	080-I-0016	
	LCP-380-01	GTE	420	101	01		420-101	GTE-420-101-01-OPENED	GTE-420-101-01-OPENED	BWW SPEC POND 1 OUTLET GATE OPENED	OPENED	DI	080-I-0016	
	LCP-380-01	GTE	420	101	01		420-101	GTE-420-101-01-REMOTE	GTE-420-101-01-REMOTE	BWW SPEC POND 1 OUTLET GATE IN REMOTE	REMOTE	DI	080-I-0016	
	LCP-380-01	GTE	420	201	01		420-201	GTE-420-201-01-CLOSE	GTE-420-201-01-CLOSE	BWW SPEC POND 2 OUTLET GATE CLOSE CMD	CLOSE	DO	080-I-0016	
	LCP-380-01	GTE	420	201	01		420-201	GTE-420-201-01-CLOSED	GTE-420-201-01-CLOSED	BWW SPEC POND 2 OUTLET GATE CLOSED	CLOSED	DI	080-I-0016	

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CS/VFD	PANEL_NO	INST TYPE	FACILITY NUMBER	LOOP	NUMBER	TAG SUFFIX	LOOP_NO	IO_TAG	TAG_NO	LOOP_TITLE	I/O FUNCTION	IO_TYPE	P+ID NO	120vac
	LCP-380-01	GTE	420	201	01		420-201	GTE-420-201-01-OPEN	GTE-420-201-01-OPEN	BWW SPEC POND 2 OUTLET GATE OPEN CMD	OPEN	DO	080-I-0016	
	LCP-380-01	GTE	420	201	01		420-201	GTE-420-201-01-OPENED	GTE-420-201-01-OPENED	BWW SPEC POND 2 OUTLET GATE OPENED	OPENED	DI	080-I-0016	
	LCP-380-01	GTE	420	201	01		420-201	GTE-420-201-01-REMOTE	GTE-420-201-01-REMOTE	BWW SPEC POND 2 OUTLET GATE IN REMOTE	REMOTE	DI	080-I-0016	
VFD	LCP-380-01	SLC	420	101	02		420-101	SLC-420-101-02-FAIL	SLC-420-101-02-FAIL	TRANSFER SLUDGE COLLECTOR 1 FAIL	FAIL	ET	080-I-0016	
VFD	LCP-380-01	SLC	420	101	02		420-101	SLC-420-101-02-START	SLC-420-101-02-START	TRANSFER SLUDGE COLLECTOR 1 START	START	ET	080-I-0016	
VFD	LCP-380-01	SLC	420	101	02		420-101	SLC-420-101-02-REMOTE	SLC-420-101-02-REMOTE	TRANSFER SLUDGE COLLECTOR 1 IN REMOTE	REMOTE	ET	080-I-0016	
VFD	LCP-380-01	SLC	420	101	02		420-101	SLC-420-101-02-RUNNING	SLC-420-101-02-RUNNING	TRANSFER SLUDGE COLLECTOR 1 RUNNING	RUNNING	ET	080-I-0016	
VFD	LCP-380-01	SLC	420	101	02		420-101	SLC-420-101-02-SC	SLC-420-101-02-SC	TRANSFER SLUDGE COLLECTOR 1 SPD CMD	SC	ET	080-I-0016	
VFD	LCP-380-01	SLC	420	101	02		420-101	SLC-420-101-02-SI	SLC-420-101-02-SI	TRANSFER SLUDGE COLLECTOR 1 SPD IND	SI	ET	080-I-0016	
VFD	LCP-380-01	SLC	420	201	02		420-201	SLC-420-201-02-START	SLC-420-201-02-START	TRANSFER SLUDGE COLLECTOR 2 START	START	ET	080-I-0016	
VFD	LCP-380-01	SLC	420	201	02		420-201	SLC-420-201-02-FAIL	SLC-420-201-02-FAIL	TRANSFER SLUDGE COLLECTOR 2 FAIL	FAIL	ET	080-I-0016	
VFD	LCP-380-01	SLC	420	201	02		420-201	SLC-420-201-02-REMOTE	SLC-420-201-02-REMOTE	TRANSFER SLUDGE COLLECTOR 2 IN REMOTE	REMOTE	ET	080-I-0016	
VFD	LCP-380-01	SLC	420	201	02		420-201	SLC-420-201-02-RUNNING	SLC-420-201-02-RUNNING	TRANSFER SLUDGE COLLECTOR 2 RUNNING	RUNNING	ET	080-I-0016	
VFD	LCP-380-01	SLC	420	201	02		420-201	SLC-420-201-02-SC	SLC-420-201-02-SC	TRANSFER SLUDGE COLLECTOR 2 SPD CMD	SC	ET	080-I-0016	
VFD	LCP-380-01	SLC	420	201	02		420-201	SLC-420-201-02-START	SLC-420-201-02-START	TRANSFER SLUDGE COLLECTOR 2 SPD IND	START	ET	080-I-0016	
	LCP-380-01	FIT	420	100	03		420-100	FIT-420-100-03-FAIL	FIT-420-100-03-FAIL	COMBINED SLUDGE FLOW TO SOLIDS DRYING PONDS FAIL	FAIL	DI	080-I-0016	
	LCP-380-01	FIT	420	100	03		420-100	FIT-420-100-03-FLOW	FIT-420-100-03-FLOW	COMBINED SLUDGE FLOW TO SOLIDS DRYING PONDS FLOW	FLOW	AI	080-I-0016	120vac
	LCP-380-01	FIT	420	100	03		420-100	FIT-420-100-03-PULSE	FIT-420-100-03-PULSE	COMBINED SLUDGE FLOW TO SOLIDS DRYING PONDS PULSE	PULSE	DI	080-I-0016	
	LCP-380-01	FCV	420	101	03		420-101	FCV-420-101-03-ZC	FCV-420-101-03-ZC	TRANSFER SLUDGE COLLECTOR 1 FCV POS CMD	ZC	AO	080-I-0016	120vac

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CS/VFD	PANEL_NO	INST TYPE	FACILITY NUMBER	LOOP	NUMBER	TAG SUFFIX	LOOP_NO	IO_TAG	TAG_NO	LOOP_TITLE	I/O FUNCTION	IO_TYPE	P+ID NO	120vac
	LCP-380-01	FCV	420	101	03		420-101	FCV-420-101-03-ZT	FCV-420-101-03-ZT	TRANSFER SLUDGE COLLECTOR 1 FCV POS IND	ZT	AI	080-I-0016	
	LCP-380-01	FCV	420	101	03		420-101	FCV-420-101-03-REMOTE	FCV-420-101-03-REMOTE	TRANSFER SLUDGE COLLECTOR 1 FCV IN REMOTE	REMOTE	DI	080-I-0016	
	LCP-380-01	FCV	420	101	03		420-101	FCV-420-101-03-FAIL	FCV-420-101-03-FAIL	TRANSFER SLUDGE COLLECTOR 1 FCV FAIL	FAIL	DI	080-I-0016	
	LCP-380-01	LIT	420	100	02		420-100	LIT-420-100-02-LEVEL	LIT-420-100-02-LEVEL	TRANSFER SLUDGE POND LEVEL	LEVEL	AI	080-I-0016	120vac
VFD	LCP-380-01	PMP	420	101	04		420-101	PMP-420-101-04-FAIL	PMP-420-101-04-FAIL	TRANSFER SLUDGE TRANSFER PUMP 1 FAIL	FAIL	ET	080-I-0016	
VFD	LCP-380-01	PMP	420	101	04		420-101	PMP-420-101-04-RUNNING	PMP-420-101-04-RUNNING	TRANSFER SLUDGE TRANSFER PUMP 1 IN REMOTE	RUNNING	ET	080-I-0016	
VFD	LCP-380-01	PMP	420	101	04		420-101	PMP-420-101-04-SC	PMP-420-101-04-SC	TRANSFER SLUDGE TRANSFER PUMP 1 RUNNING	SC	ET	080-I-0016	
VFD	LCP-380-01	PMP	420	101	04		420-101	PMP-420-101-04-SI	PMP-420-101-04-SI	TRANSFER SLUDGE TRANSFER PUMP 1 SPD IND	SI	ET	080-I-0016	
VFD	LCP-380-01	PMP	420	101	04		420-101	PMP-420-101-04-START	PMP-420-101-04-START	TRANSFER SLUDGE TRANSFER PUMP 1 SPD IND	START	ET	080-I-0016	
VFD	LCP-380-01	PMP	420	101	04		420-101	PMP-420-101-04-SC	PMP-420-101-04-SC	TRANSFER SLUDGE TRANSFER PUMP 1 START	SC	ET	080-I-0016	
	LCP-380-01	FCV	420	201	03		420-201	FCV-420-201-03-ZC	FCV-420-201-03-ZC	TRANSFER SLUDGE COLLECTOR 2 FCV POS CMD	ZC	AO	080-I-0016	120vac
	LCP-380-01	FCV	420	201	03		420-201	FCV-420-201-03-ZT	FCV-420-201-03-ZT	TRANSFER SLUDGE COLLECTOR 2 FCV POS IND	ZT	AI	080-I-0016	
	LCP-380-01	FCV	420	201	03		420-201	FCV-420-201-03-REMOTE	FCV-420-201-03-REMOTE	TRANSFER SLUDGE COLLECTOR 2 FCV IN REMOTE	REMOTE	DI	080-I-0016	
	LCP-380-01	FCV	420	201	03		420-201	FCV-420-201-03-FAIL	FCV-420-201-03-FAIL	TRANSFER SLUDGE COLLECTOR 2 FCV IN REMOTE	FAIL	DI	080-I-0016	
VFD	LCP-380-01	PMP	420	201	04		420-201	PMP-420-201-04-FAIL	PMP-420-201-04-FAIL	TRANSFER SLUDGE TRANSFER PUMP 2 FAIL	FAIL	ET	080-I-0016	
VFD	LCP-380-01	PMP	420	201	04		420-201	PMP-420-201-04-REMOTE	PMP-420-201-04-REMOTE	TRANSFER SLUDGE TRANSFER PUMP 2 IN REMOTE	REMOTE	ET	080-I-0016	
VFD	LCP-380-01	PMP	420	201	04		420-201	PMP-420-201-04-RUNNING	PMP-420-201-04-RUNNING	TRANSFER SLUDGE TRANSFER PUMP 2 RUNNING	RUNNING	ET	080-I-0016	
VFD	LCP-380-01	PMP	420	201	04		420-201	PMP-420-201-04-SC	PMP-420-201-04-SC	TRANSFER SLUDGE TRANSFER PUMP 2 SPD CMD	SC	ET	080-I-0016	
VFD	LCP-380-01	PMP	420	201	04		420-201	PMP-420-201-04-SI	PMP-420-201-04-SI	TRANSFER SLUDGE TRANSFER PUMP 2 SPD IND	SI	ET	080-I-0016	
VFD	LCP-380-01	PMP	420	201	04		420-201	PMP-420-201-04-START	PMP-420-201-04-START	TRANSFER SLUDGE TRANSFER PUMP 2 START	START	ET	080-I-0016	

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CS/VFD	PANEL_NO	INST TYPE	FACILITY NUMBER	LOOP	NUMBER	TAG SUFFIX	LOOP_NO	IO_TAG	TAG_NO	LOOP_TITLE	I/O FUNCTION	IO_TYPE	P+ID NO	120vac
	LCP-380-01	LIT	460	100	01		460-100	LIT-460-100-01-LEVEL	LIT-460-100-01-LEVEL	DECANT PUMP STATION 2 LEVEL	LEVEL	AI	080-I-0017	120vac
	LCP-380-01	FV	460	100	02		460-100	FV-460-100-02-CLOSE	FV-460-100-02-CLOSE	DECANT PUMP STATION 2 INLET VLV CLOSE CMD	CLOSE	DO	080-I-0017	
	LCP-380-01	FV	460	100	02		460-100	FV-460-100-02-CLOSED	FV-460-100-02-CLOSED	DECANT PUMP STATION 2 INLET VALVE CLOSED	CLOSED	DI	080-I-0017	
	LCP-380-01	FV	460	100	02		460-100	FV-460-100-02-FAIL	FV-460-100-02-FAIL	DECANT PUMP STATION 2 INLET VALVE FAIL	FAIL	DI	080-I-0017	
	LCP-380-01	FV	460	100	02		460-100	FV-460-100-02-OPEN	FV-460-100-02-OPEN	DECANT PUMP STATION 2 INLET VLV OPEN CMD	OPEN	DO	080-I-0017	
	LCP-380-01	FV	460	100	02		460-100	FV-460-100-02-OPENED	FV-460-100-02-OPENED	DECANT PUMP STATION 2 INLET VALVE OPENED	OPENED	DI	080-I-0017	
	LCP-380-01	FV	460	100	02		460-100	FV-460-100-02-REMOTE	FV-460-100-02-REMOTE	DECANT PUMP STATION 2 INLET VALVE IN REMOTE	REMOTE	DI	080-I-0017	
	LCP-380-01	FV	460	100	03		460-100	FV-460-100-03-CLOSE	FV-460-100-03-CLOSE	DECANT PUMP STATION 1 INLET VLV CLOSE CMD	CLOSE	DO	080-I-0017	
	LCP-380-01	FV	460	100	03		460-100	FV-460-100-03-CLOSED	FV-460-100-03-CLOSED	DECANT PUMP STATION 1 INLET VALVE CLOSED	CLOSED	DI	080-I-0017	
	LCP-380-01	FV	460	100	03		460-100	FV-460-100-03-FAIL	FV-460-100-03-FAIL	DECANT PUMP STATION 1 INLET VALVE FAIL	FAIL	DI	080-I-0017	
	LCP-380-01	FV	460	100	03		460-100	FV-460-100-03-OPEN	FV-460-100-03-OPEN	DECANT PUMP STATION 1 INLET VLV OPEN CMD	OPEN	DO	080-I-0017	
	LCP-380-01	FV	460	100	03		460-100	FV-460-100-03-OPENED	FV-460-100-03-OPENED	DECANT PUMP STATION 1 INLET VALVE OPENED	OPENED	DI	080-I-0017	
	LCP-380-01	FV	460	100	03		460-100	FV-460-100-03-REMOTE	FV-460-100-03-REMOTE	DECANT PUMP STATION 1 INLET VALVE IN REMOTE	REMOTE	DI	080-I-0017	
VFD	LCP-380-01	PMP	460	101	01		460-101	PMP-460-101-01-FAIL	PMP-460-101-01-FAIL	DECANT PUMP 1 FAIL	FAIL	ET	080-I-0017	
VFD	LCP-380-01	PMP	460	101	01		460-101	PMP-460-101-01-LEAK	PMP-460-101-01-LEAK	DECANT PUMP 1 LEAK	LEAK	ET	080-I-0017	
VFD	LCP-380-01	PMP	460	101	01		460-101	PMP-460-101-01-REMOTE	PMP-460-101-01-REMOTE	DECANT PUMP 1 IN REMOTE	REMOTE	ET	080-I-0017	
VFD	LCP-380-01	PMP	460	101	01		460-101	PMP-460-101-01-RUNNING	PMP-460-101-01-RUNNING	DECANT PUMP 1 RUNNING	RUNNING	ET	080-I-0017	
VFD	LCP-380-01	PMP	460	101	01		460-101	PMP-460-101-01-SC	PMP-460-101-01-SC	DECANT PUMP 1 SPD CMD	SC	ET	080-I-0017	
VFD	LCP-380-01	PMP	460	101	01		460-101	PMP-460-101-01-SI	PMP-460-101-01-SI	DECANT PUMP 1 SPD IND	SI	ET	080-I-0017	
VFD	LCP-380-01	PMP	460	101	01		460-101	PMP-460-101-01-START	PMP-460-101-01-START	DECANT PUMP 1 START	START	ET	080-I-0017	
VFD	LCP-380-01	PMP	460	101	01		460-101	PMP-460-101-01-TSH	PMP-460-101-01-TSH	DECANT PUMP 1 HI TEMP	TSH	ET	080-I-0017	

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CS/VFD	PANEL_NO	INST TYPE	FACILITY NUMBER	LOOP	NUMBER	TAG SUFFIX	LOOP_NO	IO_TAG	TAG_NO	LOOP_TITLE	I/O FUNCTION	IO_TYPE	P+ID NO	120vac
VFD	LCP-380-01	PMP	460	102	01		460-102	PMP-460-102-01-FAIL	PMP-460-102-01-FAIL	DECANT PUMP 2 FAIL	FAIL	ET	080-I-0017	
VFD	LCP-380-01	PMP	460	102	01		460-102	PMP-460-102-01-LEAK	PMP-460-102-01-LEAK	DECANT PUMP 2 LEAK	LEAK	ET	080-I-0017	
VFD	LCP-380-01	PMP	460	102	01		460-102	PMP-460-102-01-REMOTE	PMP-460-102-01-REMOTE	DECANT PUMP 2 IN REMOTE	REMOTE	ET	080-I-0017	
VFD	LCP-380-01	PMP	460	102	01		460-102	PMP-460-102-01-RUNNING	PMP-460-102-01-RUNNING	DECANT PUMP 2 RUNNING	RUNNING	ET	080-I-0017	
VFD	LCP-380-01	PMP	460	102	01		460-102	PMP-460-102-01-SC	PMP-460-102-01-SC	DECANT PUMP 2 SPD CMD	SC	ET	080-I-0017	
VFD	LCP-380-01	PMP	460	102	01		460-102	PMP-460-102-01-SI	PMP-460-102-01-SI	DECANT PUMP 2 SPD IND	SI	ET	080-I-0017	
VFD	LCP-380-01	PMP	460	102	01		460-102	PMP-460-102-01-START	PMP-460-102-01-START	DECANT PUMP 2 START	START	ET	080-I-0017	
VFD	LCP-380-01	PMP	460	102	01		460-102	PMP-460-102-01-TSH	PMP-460-102-01-TSH	DECANT PUMP 2 HI TEMP	TSH	ET	080-I-0017	
VFD	LCP-380-01	PMP	460	103	01		460-103	PMP-460-103-01-FAIL	PMP-460-103-01-FAIL	DECANT PUMP 3 FAIL	FAIL	ET	080-I-0017	
VFD	LCP-380-01	PMP	460	103	01		460-103	PMP-460-103-01-LEAK	PMP-460-103-01-LEAK	DECANT PUMP 3 LEAK	LEAK	ET	080-I-0017	
VFD	LCP-380-01	PMP	460	103	01		460-103	PMP-460-103-01-REMOTE	PMP-460-103-01-REMOTE	DECANT PUMP 3 IN REMOTE	REMOTE	ET	080-I-0017	
VFD	LCP-380-01	PMP	460	103	01		460-103	PMP-460-103-01-RUNNING	PMP-460-103-01-RUNNING	DECANT PUMP 3 RUNNING	RUNNING	ET	080-I-0017	
VFD	LCP-380-01	PMP	460	103	01		460-103	PMP-460-103-01-SC	PMP-460-103-01-SC	DECANT PUMP 3 SPD CMD	SC	ET	080-I-0017	
VFD	LCP-380-01	PMP	460	103	01		460-103	PMP-460-103-01-SI	PMP-460-103-01-SI	DECANT PUMP 3 SPD IND	SI	ET	080-I-0017	
VFD	LCP-380-01	PMP	460	103	01		460-103	PMP-460-103-01-START	PMP-460-103-01-START	DECANT PUMP 3 START	START	ET	080-I-0017	
VFD	LCP-380-01	PMP	460	103	01		460-103	PMP-460-103-01-TSH	PMP-460-103-01-TSH	DECANT PUMP 3 HI TEMP	TSH	ET	080-I-0017	
	LCP-380-01	FIT	460	200	01		460-200	FIT-460-200-01-FAIL	FIT-460-200-01-FAIL	PLANT RECYCLE PUMPS FLOW FAIL	FAIL	DI	080-I-0017	
	LCP-380-01	FIT	460	200	01		460-200	FIT-460-200-01-FLOW	FIT-460-200-01-FLOW	PLANT RECYCLE PUMPS FLOW	FLOW	AI	080-I-0017	120vac
	LCP-380-01	FIT	460	200	01		460-200	FIT-460-200-01-PULSE	FIT-460-200-01-PULSE	PLANT RECYCLE PUMPS FLOW PULSE	PULSE	DI	080-I-0017	
	LCP-380-01	LIT	440	103	01		440-103	LIT-440-103-01-LEVEL	LIT-440-103-01-LEVEL	SOLIDS DRYING BED 1 LEVEL	LEVEL	AI	080-I-0018	120vac
	LCP-380-01	LIT	440	203	01		440-203	LIT-440-203-01-LEVEL	LIT-440-203-01-LEVEL	SOLIDS DRYING BED 2 LEVEL	LEVEL	AI	080-I-0018	120vac

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CS/VFD	PANEL_NO	INST TYPE	FACILITY NUMBER	LOOP	NUMBER	TAG SUFFIX	LOOP_NO	IO_TAG	TAG_NO	LOOP_TITLE	I/O FUNCTION	IO_TYPE	P+ID NO	120vac
	LCP-380-01	LIT	380	101	01		380-101	LIT-380-101-01-LEVEL	LIT-380-101-01-LEVEL	H2SO4 STOARGE TANK LEVEL	LEVEL	AI	080-I-0019	120vac
	LCP-380-01	PMP	380	101	01		380-101	PMP-380-101-01-ALM	PMP-380-101-01-ALM	H2SO4 FEED PUMP 1	ALM	DI	080-I-0019	
	LCP-380-01	PMP	380	101	01		380-101	PMP-380-101-01-PSH	PMP-380-101-01-PSH	H2SO4 FEED PUMP 1 HIGH DISCHG PRESS	PSH	DI	080-I-0019	
	LCP-380-01	PMP	380	101	01		380-101	PMP-380-101-01-REMOTE	PMP-380-101-01-REMOTE	H2SO4 FEED PUMP 1 IN REMOTE	REMOTE	DI	080-I-0019	
	LCP-380-01	PMP	380	101	01		380-101	PMP-380-101-01-RUNNING	PMP-380-101-01-RUNNING	H2SO4 FEED PUMP 1 RUNNING	RUNNING	DI	080-I-0019	
	LCP-380-01	PMP	380	101	01		380-101	PMP-380-101-01-START	PMP-380-101-01-START	H2SO4 FEED PUMP 1 START	START	DO	080-I-0019	
	LCP-380-01	PMP	380	101	01		380-101	PMP-380-101-01-SC	PMP-380-101-01-SC	H2SO4 FEED PUMP 1 SPD CMD	SC	AO	080-I-0019	
	LCP-380-01	PMP	380	101	02		380-101	PMP-380-101-02-ALM	PMP-380-101-02-ALM	H2SO4 FEED PUMP 2	ALM	DI	080-I-0019	
	LCP-380-01	PMP	380	101	02		380-101	PMP-380-101-02-PSH	PMP-380-101-02-PSH	H2SO4 FEED PUMP 2 HIGH DISCHG PRESS	PSH	DI	080-I-0019	
	LCP-380-01	PMP	380	101	02		380-101	PMP-380-101-02-REMOTE	PMP-380-101-02-REMOTE	H2SO4 FEED PUMP 2 IN REMOTE	REMOTE	DI	080-I-0019	
	LCP-380-01	PMP	380	101	02		380-101	PMP-380-101-02-RUNNING	PMP-380-101-02-RUNNING	H2SO4 FEED PUMP 2 RUNNING	RUNNING	DI	080-I-0019	
	LCP-380-01	PMP	380	101	02		380-101	PMP-380-101-02-START	PMP-380-101-02-START	H2SO4 FEED PUMP 2 START	START	DO	080-I-0019	
	LCP-380-01	PMP	380	101	02		380-101	PMP-380-101-02-SC	PMP-380-101-02-SC	H2SO4 FEED PUMP 2 SPD CMD	SC	AO	080-I-0019	
	LCP-380-01	PMP	380	101	03		380-101	PMP-380-101-03-ALM	PMP-380-101-03-ALM	H2SO4 FEED PUMP 3	ALM	DI	080-I-0019	
	LCP-380-01	PMP	380	101	03		380-101	PMP-380-101-03-PSH	PMP-380-101-03-PSH	H2SO4 FEED PUMP 3 HIGH DISCHG PRESS	PSH	DI	080-I-0019	
	LCP-380-01	PMP	380	101	03		380-101	PMP-380-101-03-REMOTE	PMP-380-101-03-REMOTE	H2SO4 FEED PUMP 3 IN REMOTE	REMOTE	DI	080-I-0019	
	LCP-380-01	PMP	380	101	03		380-101	PMP-380-101-03-RUNNING	PMP-380-101-03-RUNNING	H2SO4 FEED PUMP 3 RUNNING	RUNNING	DI	080-I-0019	
	LCP-380-01	PMP	380	101	03		380-101	PMP-380-101-03-START	PMP-380-101-03-START	H2SO4 FEED PUMP 3 START	START	DO	080-I-0019	
	LCP-380-01	PMP	380	101	03		380-101	PMP-380-101-03-SC	PMP-380-101-03-SC	H2SO4 FEED PUMP 3 SPD CMD	SC	AO	080-I-0019	
	LCP-380-01	LSH	380	100	01		380-100	LSH-380-100-01-LSH	LSH-380-100-01-LSH	H2SO4 STORAGE TANK HIGH LEVEL	LSH	DI	080-I-0019	120vac
	LCP-380-01	SWR	380	200	02		380-200	SWR-380-200-02-FSH	SWR-380-200-02-FSH	FECL & H2SO4 SAFETY SHOWER	FSH	DI	080-I-0020	

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CS/VFD	PANEL_NO	INST TYPE	FACILITY NUMBER	LOOP	NUMBER	TAG SUFFIX	LOOP_NO	IO_TAG	TAG_NO	LOOP_TITLE	I/O FUNCTION	IO_TYPE	P+ID NO	120vac
	LCP-380-01	PMP	380	201	01		380-201	PMP-380-201-01-FAIL	PMP-380-201-01-FAIL	FECL METERING PUMP 1 FAIL	FAIL	DI	080-I-0020	
	LCP-380-01	PMP	380	201	01		380-201	PMP-380-201-01-REMOTE	PMP-380-201-01-REMOTE	FECL METERING PUMP 1 REMOTE	REMOTE	DI	080-I-0020	
	LCP-380-01	PMP	380	201	01		380-201	PMP-380-201-01-RUNNING	PMP-380-201-01-RUNNING	FECL METERING PUMP 1 RUNNING	RUNNING	DI	080-I-0020	
	LCP-380-01	PMP	380	201	01		380-201	PMP-380-201-01-START	PMP-380-201-01-START	FECL METERING PUMP 1 START	START	DO	080-I-0020	
	LCP-380-01	PMP	380	201	02		380-201	PMP-380-201-02-FAIL	PMP-380-201-02-FAIL	FECL METERING PUMP 2 FAIL	FAIL	DI	080-I-0020	
	LCP-380-01	PMP	380	201	02		380-201	PMP-380-201-02-REMOTE	PMP-380-201-02-REMOTE	FECL METERING PUMP 2 REMOTE	REMOTE	DI	080-I-0020	
	LCP-380-01	PMP	380	201	02		380-201	PMP-380-201-02-RUNNING	PMP-380-201-02-RUNNING	FECL METERING PUMP 2 RUNNING	RUNNING	DI	080-I-0020	
	LCP-380-01	PMP	380	201	02		380-201	PMP-380-201-02-START	PMP-380-201-02-START	FECL METERING PUMP 2 START	START	DO	080-I-0020	
	LCP-380-01	PMP	380	201	03		380-201	PMP-380-201-03-FAIL	PMP-380-201-03-FAIL	FECL METERING PUMP 3 FAIL	FAIL	DI	080-I-0020	
	LCP-380-01	PMP	380	201	03		380-201	PMP-380-201-03-REMOTE	PMP-380-201-03-REMOTE	FECL METERING PUMP 3 REMOTE	REMOTE	DI	080-I-0020	
	LCP-380-01	PMP	380	201	03		380-201	PMP-380-201-03-RUNNING	PMP-380-201-03-RUNNING	FECL METERING PUMP 3 RUNNING	RUNNING	DI	080-I-0020	
	LCP-380-01	PMP	380	201	03		380-201	PMP-380-201-03-START	PMP-380-201-03-START	FECL METERING PUMP 3 START	START	DO	080-I-0020	
	LCP-380-01	FIT	380	202	01		380-202	FIT-380-202-01-FAIL	FIT-380-202-01-FAIL	FECL FLOW TO BASIN 1 RAPID MIXER 2 FAIL	FAIL	DI	080-I-0020	
	LCP-380-01	FIT	380	202	01		380-202	FIT-380-202-01-FLOW	FIT-380-202-01-FLOW	FECL FLOW TO BASIN 1 RAPID MIXER 2 FLOW	FLOW	AI	080-I-0020	120vac
	LCP-380-01	FIT	380	202	01		380-202	FIT-380-202-01-PULSE	FIT-380-202-01-PULSE	FECL FLOW TO BASIN 1 RAPID MIXER 2 PULSE	PULSE	DI	080-I-0020	
	LCP-380-01	SWR	380	201	01		380-201	SWR-380-201-01-FSH	SWR-380-201-01-FSH	FECL TANK AREA SAFETY SHOWER	FSH	DI	080-I-0020	
	LCP-380-01	LSH	380	211	01		380-211	LSH-380-211-01-LSH	LSH-380-211-01-LSH	FECL TANK CONTAINMENT HIGH LEVEL	LSH	DI	080-I-0020	
	LCP-380-01	LSH	380	200	01		380-200	LSH-380-200-01-LSH	LSH-380-200-01-LSH	FECL STORAGE TANK HIGH LEVEL	LSH	DI	080-I-0020	120vac
	LCP-380-01	LIT	380	301	01		380-301	LIT-380-301-01-LEVEL	LIT-380-301-01-LEVEL	SHC STORAGE TANK LEVEL	LEVEL	AI	080-I-0021	120vac
	LCP-380-01	PMP	380	301	01		380-301	PMP-380-301-01-ALM	PMP-380-301-01-ALM	SHC FEED PUMP 1	ALM	DI	080-I-0021	
	LCP-380-01	PMP	380	301	01		380-301	PMP-380-301-01-REMOTE	PMP-380-301-01-REMOTE	SHC FEED PUMP 1 IN REMOTE	REMOTE	DI	080-I-0021	

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CS/VFD	PANEL_NO	INST TYPE	FACILITY NUMBER	LOOP	NUMBER	TAG SUFFIX	LOOP_NO	IO_TAG	TAG_NO	LOOP_TITLE	I/O FUNCTION	IO_TYPE	P+ID NO	120vac
	LCP-380-01	PMP	380	301	01		380-301	PMP-380-301-01-RUNNING	PMP-380-301-01-RUNNING	SHC FEED PUMP 1 RUNNING	RUNNING	DI	080-I-0021	
	LCP-380-01	PMP	380	301	01		380-301	PMP-380-301-01-START	PMP-380-301-01-START	SHC FEED PUMP 1 START	START	DO	080-I-0021	
	LCP-380-01	PSH	380	301	01		380-301	PSH-380-301-01-PSH	PSH-380-301-01-PSH	SHC FEED PUMP 1 HIGH DISCHG PRESS	PSH	DI	080-I-0021	
	LCP-380-01	PMP	380	301	01		380-301	PMP-380-301-01-SC	PMP-380-301-01-SC	SHC FEED PUMP 1 SPD CMD	SC	AO	080-I-0021	
	LCP-380-01	PMP	380	301	02		380-301	PMP-380-301-02-ALM	PMP-380-301-02-ALM	SHC FEED PUMP 2	ALM	DI	080-I-0021	
	LCP-380-01	PMP	380	301	02		380-301	PMP-380-301-02-REMOTE	PMP-380-301-02-REMOTE	SHC FEED PUMP 2 IN REMOTE	REMOTE	DI	080-I-0021	
	LCP-380-01	PMP	380	301	02		380-301	PMP-380-301-02-RUNNING	PMP-380-301-02-RUNNING	SHC FEED PUMP 2 RUNNING	RUNNING	DI	080-I-0021	
	LCP-380-01	PMP	380	301	02		380-301	PMP-380-301-02-START	PMP-380-301-02-START	SHC FEED PUMP 2 START	START	DO	080-I-0021	
	LCP-380-01	PSH	380	301	02		380-301	PSH-380-301-02-PSH	PSH-380-301-02-PSH	SHC FEED PUMP 2 HIGH DISCHG PRESS	PSH	DI	080-I-0021	
	LCP-380-01	PMP	380	301	02		380-301	PMP-380-301-02-SC	PMP-380-301-02-SC	SHC FEED PUMP 2 SPD CMD	SC	AO	080-I-0021	
	LCP-380-01	LSH	380	300	01		380-300	LSH-380-300-01-LSH	LSH-380-300-01-LSH	SHC STORAGE TANK HIGH LEVEL	LSH	DI	080-I-0021	120vac
	LCP-380-01	LIT	380	400	01		380-400	LIT-380-400-01-LEVEL	LIT-380-400-01-LEVEL	NAOH STORAGE TANK LEVEL	LEVEL	AI	080-I-0022	120vac
	LCP-380-01	PMP	380	401	01		380-401	PMP-380-401-01-ALM	PMP-380-401-01-ALM	NAOH FEED PUMP 2	ALM	DI	080-I-0022	
	LCP-380-01	PMP	380	401	01		380-401	PMP-380-401-01-PSH	PMP-380-401-01-PSH	NAOH FEED PUMP 1 DISCHG HIGH PRESS	PSH	DI	080-I-0022	
	LCP-380-01	PMP	380	401	01		380-401	PMP-380-401-01-REMOTE	PMP-380-401-01-REMOTE	NAOH FEED PUMP 1 IN REMOTE	REMOTE	DI	080-I-0022	
	LCP-380-01	PMP	380	401	01		380-401	PMP-380-401-01-RUNNING	PMP-380-401-01-RUNNING	NAOH FEED PUMP 1 RUNNING	RUNNING	DI	080-I-0022	
	LCP-380-01	PMP	380	401	01		380-401	PMP-380-401-01-START	PMP-380-401-01-START	NAOH FEED PUMP 1 START	START	DO	080-I-0022	
	LCP-380-01	PMP	380	401	01		380-401	PMP-380-401-01-SC	PMP-380-401-01-SC	NAOH FEED PUMP 1 SPD CMD	SC	AO	080-I-0022	
	LCP-380-01	PMP	380	401	02		380-401	PMP-380-401-02-ALM	PMP-380-401-02-ALM	NAOH FEED PUMP 2	ALM	DI	080-I-0022	
	LCP-380-01	PMP	380	401	02		380-401	PMP-380-401-02-PSH	PMP-380-401-02-PSH	NAOH FEED PUMP 2 DISCHG HIGH PRESS	PSH	DI	080-I-0022	
	LCP-380-01	PMP	380	401	02		380-401	PMP-380-401-02-REMOTE	PMP-380-401-02-REMOTE	NAOH FEED PUMP 2 IN REMOTE	REMOTE	DI	080-I-0022	

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CS/VFD	PANEL_NO	INST TYPE	FACILITY NUMBER	LOOP	NUMBER	TAG SUFFIX	LOOP_NO	IO_TAG	TAG_NO	LOOP_TITLE	I/O FUNCTION	IO_TYPE	P+ID NO	120vac
	LCP-380-01	PMP	380	401	02		380-401	PMP-380-401-02-RUNNING	PMP-380-401-02-RUNNING	NAOH FEED PUMP 2 RUNNING	RUNNING	DI	080-I-0022	
	LCP-380-01	PMP	380	401	02		380-401	PMP-380-401-02-START	PMP-380-401-02-START	NAOH FEED PUMP 2 START	START	DO	080-I-0022	
	LCP-380-01	PMP	380	401	02		380-401	PMP-380-401-02-SC	PMP-380-401-02-SC	NAOH FEED PUMP 2 SPD CMD	SC	AO	080-I-0022	
	LCP-380-01	PMP	380	401	03		380-401	PMP-380-401-03-ALM	PMP-380-401-03-ALM	NAOH FEED PUMP 3	ALM	DI	080-I-0022	
	LCP-380-01	PMP	380	401	03		380-401	PMP-380-401-03-PSH	PMP-380-401-03-PSH	NAOH FEED PUMP 3 DISCHG HIGH PRESS	PSH	DI	080-I-0022	
	LCP-380-01	PMP	380	401	03		380-401	PMP-380-401-03-REMOTE	PMP-380-401-03-REMOTE	NAOH FEED PUMP 3 IN REMOTE	REMOTE	DI	080-I-0022	
	LCP-380-01	PMP	380	401	03		380-401	PMP-380-401-03-RUNNING	PMP-380-401-03-RUNNING	NAOH FEED PUMP 3 RUNNING	RUNNING	DI	080-I-0022	
	LCP-380-01	PMP	380	401	03		380-401	PMP-380-401-03-START	PMP-380-401-03-START	NAOH FEED PUMP 3 START	START	DO	080-I-0022	
	LCP-380-01	PMP	380	401	03		380-401	PMP-380-401-03-SC	PMP-380-401-03-SC	NAOH FEED PUMP 3 SPD CMD	SC	AO	080-I-0022	
	LCP-380-01	SWR	380	410	01		380-410	SWR-380-410-01-FSH	SWR-380-410-01-FSH	NAOH AREA SAFETY SHOWER	FSH	DI	080-I-0022	
	LCP-380-01	LSH	380	411	01		380-411	LSH-380-411-01-LSH	LSH-380-411-01-LSH	NAOH AREA CONTAINMENT SUMP HIGH LEVEL	LSH	DI	080-I-0022	
	LCP-380-01	LSH	380	400	01		380-400	LSH-380-400-01-LSH	LSH-380-400-01-LSH	NAOH STORAGE TANK HIGH LEVEL	LSH	DI	080-I-0022	120vac
	LCP-380-01	WIT	380	500	01		380-500	WIT-380-500-01-LEVEL	WIT-380-500-01-LEVEL	CATIONIC POLYMER TOTE LEVEL	LEVEL	AI	080-I-0023	120vac
	LCP-380-01	FV	380	501	01		380-501	FV-380-501-01-CLOSE	FV-380-501-01-CLOSE	CATIONIC POLYMER TANK 1 INLET VLV CLOSE CMD	CLOSE	DO	080-I-0023	
	LCP-380-01	FV	380	501	01		380-501	FV-380-501-01-CLOSED	FV-380-501-01-CLOSED	CATIONIC POLYMER TANK 1 INLET VLV CLOSED	CLOSED	DI	080-I-0023	
	LCP-380-01	FV	380	501	01		380-501	FV-380-501-01-FAIL	FV-380-501-01-FAIL	CATIONIC POLYMER TANK 1 INLET VLV FAIL	FAIL	DI	080-I-0023	
	LCP-380-01	FV	380	501	01		380-501	FV-380-501-01-OPEN	FV-380-501-01-OPEN	CATIONIC POLYMER TANK 1 INLET VLV OPEN CMD	OPEN	DO	080-I-0023	
	LCP-380-01	FV	380	501	01		380-501	FV-380-501-01-OPENED	FV-380-501-01-OPENED	CATIONIC POLYMER TANK 1 INLET VLV OPENED	OPENED	DI	080-I-0023	
	LCP-380-01	FV	380	501	01		380-501	FV-380-501-01-REMOTE	FV-380-501-01-REMOTE	CATIONIC POLYMER TANK 1 INLET VLV IN REMOTE	REMOTE	DI	080-I-0023	
	LCP-380-01	LIT	380	501	02		380-501	LIT-380-501-02-LEVEL	LIT-380-501-02-LEVEL	CATIONIC POLYMER TANK 1 LEVEL	LEVEL	AI	080-I-0023	120vac
	LCP-380-01	MXR	380	501	01		380-501	MXR-380-501-01-FAIL	MXR-380-501-01-FAIL	NONIONIC OR CATIONIC POLYMER PBU 1 FAIL	FAIL	DI	080-I-0023	

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CS/VFD	PANEL_NO	INST TYPE	FACILITY NUMBER	LOOP	NUMBER	TAG SUFFIX	LOOP_NO	IO_TAG	TAG_NO	LOOP_TITLE	I/O FUNCTION	IO_TYPE	P+ID NO	120vac
	LCP-380-01	MXR	380	501	01		380-501	MXR-380-501-01-REMOTE	MXR-380-501-01-REMOTE	NONIONIC OR CATIONIC POLYMER PBU 1 IN REMOTE	REMOTE	DI	080-I-0023	
	LCP-380-01	MXR	380	501	01		380-501	MXR-380-501-01-RUNNING	MXR-380-501-01-RUNNING	NONIONIC OR CATIONIC POLYMER PBU 1 RUNNING	RUNNING	DI	080-I-0023	
	LCP-380-01	MXR	380	501	01		380-501	MXR-380-501-01-START	MXR-380-501-01-START	NONIONIC OR CATIONIC POLYMER PBU 1 START	START	DO	080-I-0023	
	LCP-380-01	PMP	380	501	01		380-501	PMP-380-501-01-ALM	PMP-380-501-01-ALM	CATIONIC POLYMER FEED PUMP 1	ALM	DI	080-I-0023	
	LCP-380-01	PMP	380	501	01		380-501	PMP-380-501-01-PSH	PMP-380-501-01-PSH	CATIONIC POLYMER FEED PUMP 1 HIGH DISCHG PRESS	PSH	DI	080-I-0023	
	LCP-380-01	PMP	380	501	01		380-501	PMP-380-501-01-REMOTE	PMP-380-501-01-REMOTE	CATIONIC POLYMER FEED PUMP 1 IN REMOTE	REMOTE	DI	080-I-0023	
	LCP-380-01	PMP	380	501	01		380-501	PMP-380-501-01-RUNNING	PMP-380-501-01-RUNNING	CATIONIC POLYMER FEED PUMP 1 RUNNING	RUNNING	DI	080-I-0023	
	LCP-380-01	PMP	380	501	01		380-501	PMP-380-501-01-START	PMP-380-501-01-START	CATIONIC POLYMER FEED PUMP 1 START	START	DO	080-I-0023	
	LCP-380-01	PMP	380	501	01		380-501	PMP-380-501-01-SC	PMP-380-501-01-SC	CATIONIC POLYMER FEED PUMP 1 SPD CMD	SC	AO	080-I-0023	
	LCP-380-01	FV	380	501	02		380-501	FV-380-501-02-CLOSE	FV-380-501-02-CLOSE	CATIONIC POLYMER TANK 1 DISCH VLV CLOSE CMD	CLOSE	DO	080-I-0023	
	LCP-380-01	FV	380	501	02		380-501	FV-380-501-02-CLOSED	FV-380-501-02-CLOSED	CATIONIC POLYMER TANK 1 DISCH VLV CLOSED	CLOSED	DI	080-I-0023	
	LCP-380-01	FV	380	501	02		380-501	FV-380-501-02-FAIL	FV-380-501-02-FAIL	CATIONIC POLYMER TANK 1 DISCH VLV FAIL	FAIL	DI	080-I-0023	
	LCP-380-01	FV	380	501	02		380-501	FV-380-501-02-OPEN	FV-380-501-02-OPEN	CATIONIC POLYMER TANK 1 DISCH VLV OPEN CMD	OPEN	DO	080-I-0023	
	LCP-380-01	FV	380	501	02		380-501	FV-380-501-02-OPENED	FV-380-501-02-OPENED	CATIONIC POLYMER TANK 1 DISCH VLV OPENED	OPENED	DI	080-I-0023	
	LCP-380-01	FV	380	501	02		380-501	FV-380-501-02-REMOTE	FV-380-501-02-REMOTE	CATIONIC POLYMER TANK 1 DISCH VLV IN REMOTE	REMOTE	DI	080-I-0023	
	LCP-380-01	LIT	380	502	02		380-502	LIT-380-502-02-LEVEL	LIT-380-502-02-LEVEL	CATIONIC POLYMER TANK 2 LEVEL	LEVEL	AI	080-I-0023	120vac
	LCP-380-01	MXR	380	501	02		380-501	MXR-380-501-02-FAIL	MXR-380-501-02-FAIL	NONIONIC OR CATIONIC POLYMER PBU 2 FAIL	FAIL	DI	080-I-0023	
	LCP-380-01	MXR	380	501	02		380-501	MXR-380-501-02-REMOTE	MXR-380-501-02-REMOTE	NONIONIC OR CATIONIC POLYMER PBU 2 IN REMOTE	REMOTE	DI	080-I-0023	
	LCP-380-01	MXR	380	501	02		380-501	MXR-380-501-02-RUNNING	MXR-380-501-02-RUNNING	NONIONIC OR CATIONIC POLYMER PBU 2 RUNNING	RUNNING	DI	080-I-0023	
	LCP-380-01	MXR	380	501	02		380-501	MXR-380-501-02-START	MXR-380-501-02-START	NONIONIC OR CATIONIC POLYMER PBU 2 START	START	DO	080-I-0023	
	LCP-380-01	PMP	380	501	02		380-501	PMP-380-501-02-ALM	PMP-380-501-02-ALM	CATIONIC POLYMER FEED PUMP 2	ALM	DI	080-I-0023	

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CS/VFD	PANEL_NO	INST TYPE	FACILITY NUMBER	LOOP	NUMBER	TAG SUFFIX	LOOP_NO	IO_TAG	TAG_NO	LOOP_TITLE	I/O FUNCTION	IO_TYPE	P+ID NO	120vac
	LCP-380-01	PMP	380	501	02		380-501	PMP-380-501-02-PSH	PMP-380-501-02-PSH	CATIONIC POLYMER FEED PUMP 2 HIGH DISCHG PRESS	PSH	DI	080-I-0023	
	LCP-380-01	PMP	380	501	02		380-501	PMP-380-501-02-REMOTE	PMP-380-501-02-REMOTE	CATIONIC POLYMER FEED PUMP 2 IN REMOTE	REMOTE	DI	080-I-0023	
	LCP-380-01	PMP	380	501	02		380-501	PMP-380-501-02-RUNNING	PMP-380-501-02-RUNNING	CATIONIC POLYMER FEED PUMP 2 RUNNING	RUNNING	DI	080-I-0023	
	LCP-380-01	PMP	380	501	02		380-501	PMP-380-501-02-START	PMP-380-501-02-START	CATIONIC POLYMER FEED PUMP 2 START	START	DO	080-I-0023	
	LCP-380-01	PMP	380	501	02		380-501	PMP-380-501-02-SC	PMP-380-501-02-SC	CATIONIC POLYMER FEED PUMP 2 SPD CMD	SC	AO	080-I-0023	
	LCP-380-01	FV	380	501	03		380-501	FV-380-501-03-CLOSE	FV-380-501-03-CLOSE	CATIONIC POLYMER TANK 2 INLET VLV CLOSE CMD	CLOSE	DO	080-I-0023	
	LCP-380-01	FV	380	501	03		380-501	FV-380-501-03-CLOSED	FV-380-501-03-CLOSED	CATIONIC POLYMER TANK 2 INLET VLV CLOSED	CLOSED	DI	080-I-0023	
	LCP-380-01	FV	380	501	03		380-501	FV-380-501-03-FAIL	FV-380-501-03-FAIL	CATIONIC POLYMER TANK 2 INLET VLV FAIL	FAIL	DI	080-I-0023	
	LCP-380-01	FV	380	501	03		380-501	FV-380-501-03-OPEN	FV-380-501-03-OPEN	CATIONIC POLYMER TANK 2 INLET VLV OPEN CMD	OPEN	DO	080-I-0023	
	LCP-380-01	FV	380	501	03		380-501	FV-380-501-03-OPENED	FV-380-501-03-OPENED	CATIONIC POLYMER TANK 2 INLET VLV OPENED	OPENED	DI	080-I-0023	
	LCP-380-01	FV	380	501	03		380-501	FV-380-501-03-REMOTE	FV-380-501-03-REMOTE	CATIONIC POLYMER TANK 2 INLET VLV IN REMOTE	REMOTE	DI	080-I-0023	
	LCP-380-01	FV	380	501	04		380-501	FV-380-501-04-CLOSE	FV-380-501-04-CLOSE	CATIONIC POLYMER TANK 2 DISCH VLV CLOSE CMD	CLOSE	DO	080-I-0023	
	LCP-380-01	FV	380	501	04		380-501	FV-380-501-04-CLOSED	FV-380-501-04-CLOSED	CATIONIC POLYMER TANK 2 DISCH VLV CLOSED	CLOSED	DI	080-I-0023	
	LCP-380-01	FV	380	501	04		380-501	FV-380-501-04-FAIL	FV-380-501-04-FAIL	CATIONIC POLYMER TANK 2 DISCH VLV FAIL	FAIL	DI	080-I-0023	
	LCP-380-01	FV	380	501	04		380-501	FV-380-501-04-OPEN	FV-380-501-04-OPEN	CATIONIC POLYMER TANK 2 DISCH VLV OPEN CMD	OPEN	DO	080-I-0023	
	LCP-380-01	FV	380	501	04		380-501	FV-380-501-04-OPENED	FV-380-501-04-OPENED	CATIONIC POLYMER TANK 2 DISCH VLV OPENED	OPENED	DI	080-I-0023	
	LCP-380-01	FV	380	501	04		380-501	FV-380-501-04-REMOTE	FV-380-501-04-REMOTE	CATIONIC POLYMER TANK 2 DISCH VLV IN REMOTE	REMOTE	DI	080-I-0023	
	LCP-380-01	SWR	380	510	01		380-510	SWR-380-510-01-FSH	SWR-380-510-01-FSH	CATIONIC POLYMER STORAGE AREA SAFETY SHOWER	FSH	DI	080-I-0023	
	LCP-380-01	LSH	380	511	01		380-511	LSH-380-511-01-LSH	LSH-380-511-01-LSH	CATIONIC POLYMER TANK CONTAINMENT LEVEL HIGH	LSH	DI	080-I-0023	
	LCP-380-01	WIT	380	500	01		380-500	WIT-380-500-01-LEVEL	WIT-380-500-01-LEVEL	ANIONIC POLYMER TOTE 1 LEVEL	LEVEL	AI	080-I-0024	120vac

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CS/VFD	PANEL_NO	INST TYPE	FACILITY NUMBER	LOOP	NUMBER	TAG SUFFIX	LOOP_NO	IO_TAG	TAG_NO	LOOP_TITLE	I/O FUNCTION	IO_TYPE	P+ID NO	120vac
	LCP-380-01	WIT	380	500	02		380-500	WIT-380-500-02-LEVEL	WIT-380-500-02-LEVEL	ANIONIC POLYMER TOTE 2 LEVEL	LEVEL	AI	080-I-0024	120vac
	LCP-380-01	FV	380	501	01		380-501	FV-380-501-01-CLOSE	FV-380-501-01-CLOSE	ANIONIC POLYMER TANK 1 INLET VLV CLOSE CMD	CLOSE	DO	080-I-0024	
	LCP-380-01	FV	380	501	01		380-501	FV-380-501-01-CLOSED	FV-380-501-01-CLOSED	ANIONIC POLYMER TANK 1 INLET VLV CLOSED	CLOSED	DI	080-I-0024	
	LCP-380-01	FV	380	501	01		380-501	FV-380-501-01-FAIL	FV-380-501-01-FAIL	ANIONIC POLYMER TANK 1 INLET VLV FAIL	FAIL	DI	080-I-0024	
	LCP-380-01	FV	380	501	01		380-501	FV-380-501-01-OPEN	FV-380-501-01-OPEN	ANIONIC POLYMER TANK 1 INLET VLV OPEN CMD	OPEN	DO	080-I-0024	
	LCP-380-01	FV	380	501	01		380-501	FV-380-501-01-OPENED	FV-380-501-01-OPENED	ANIONIC POLYMER TANK 1 INLET VLV OPENED	OPENED	DI	080-I-0024	
	LCP-380-01	FV	380	501	01		380-501	FV-380-501-01-REMOTE	FV-380-501-01-REMOTE	ANIONIC POLYMER TANK 1 INLET VLV IN REMOTE	REMOTE	DI	080-I-0024	
	LCP-380-01	LIT	380	601	02		380-601	LIT-380-601-02-LEVEL	LIT-380-601-02-LEVEL	ANIONIC POLYMER TANK 2 LEVEL	LEVEL	AI	080-I-0024	120vac
	LCP-380-01	MXR	380	501	01		380-501	MXR-380-501-01-FAIL	MXR-380-501-01-FAIL	ANIONIC POLYMER TANK 1 MIXER FAIL	FAIL	DI	080-I-0024	
	LCP-380-01	MXR	380	501	01		380-501	MXR-380-501-01-REMOTE	MXR-380-501-01-REMOTE	ANIONIC POLYMER TANK 1 MIXER IN REMOTE	REMOTE	DI	080-I-0024	
	LCP-380-01	MXR	380	501	01		380-501	MXR-380-501-01-RUNNING	MXR-380-501-01-RUNNING	ANIONIC POLYMER TANK 1 MIXER RUNNING	RUNNING	DI	080-I-0024	
	LCP-380-01	MXR	380	501	01		380-501	MXR-380-501-01-START	MXR-380-501-01-START	ANIONIC POLYMER TANK 1 MIXER START	START	DO	080-I-0024	
	LCP-380-01	FV	380	501	02		380-501	FV-380-501-02-CLOSE	FV-380-501-02-CLOSE	ANIONIC POLYMER TANK 1 DISCH VLV CLOSE CMD	CLOSE	DO	080-I-0024	
	LCP-380-01	FV	380	501	02		380-501	FV-380-501-02-CLOSED	FV-380-501-02-CLOSED	ANIONIC POLYMER TANK 1 DISCH VLV CLOSED	CLOSED	DI	080-I-0024	
	LCP-380-01	FV	380	501	02		380-501	FV-380-501-02-FAIL	FV-380-501-02-FAIL	ANIONIC POLYMER TANK 1 DISCH VLV FAIL	FAIL	DI	080-I-0024	
	LCP-380-01	FV	380	501	02		380-501	FV-380-501-02-OPEN	FV-380-501-02-OPEN	ANIONIC POLYMER TANK 1 DISCH VLV OPEN CMD	OPEN	DO	080-I-0024	
	LCP-380-01	FV	380	501	02		380-501	FV-380-501-02-OPENED	FV-380-501-02-OPENED	ANIONIC POLYMER TANK 1 DISCH VLV OPENED	OPENED	DI	080-I-0024	
	LCP-380-01	FV	380	501	02		380-501	FV-380-501-02-REMOTE	FV-380-501-02-REMOTE	ANIONIC POLYMER TANK 1 DISCH VLV IN REMOTE	REMOTE	DI	080-I-0024	
	LCP-380-01	LIT	380	602	02		380-602	LIT-380-602-02-LEVEL	LIT-380-602-02-LEVEL	ANIONIC POLYMER TANK 1 LEVEL	LEVEL	AI	080-I-0024	120vac
	LCP-380-01	MXR	380	501	02		380-501	MXR-380-501-02-FAIL	MXR-380-501-02-FAIL	ANIONIC POLYMER TANK 2 MIXER FAIL	FAIL	DI	080-I-0024	
	LCP-380-01	MXR	380	501	02		380-501	MXR-380-501-02-REMOTE	MXR-380-501-02-REMOTE	ANIONIC POLYMER TANK 2 MIXER IN REMOTE	REMOTE	DI	080-I-0024	

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CS/VFD	PANEL_NO	INST TYPE	FACILITY NUMBER	LOOP	NUMBER	TAG SUFFIX	LOOP_NO	IO_TAG	TAG_NO	LOOP_TITLE	I/O FUNCTION	IO_TYPE	P+ID NO	120vac
	LCP-380-01	MXR	380	501	02		380-501	MXR-380-501-02-RUNNING	MXR-380-501-02-RUNNING	ANIONIC POLYMER TANK 2 MIXER RUNNING	RUNNING	DI	080-I-0024	
	LCP-380-01	MXR	380	501	02		380-501	MXR-380-501-02-START	MXR-380-501-02-START	ANIONIC POLYMER TANK 2 MIXER START	START	DO	080-I-0024	
	LCP-380-01	FV	380	501	03		380-501	FV-380-501-03-CLOSE	FV-380-501-03-CLOSE	ANIONIC POLYMER TANK 2 INLET VLV CLOSE CMD	CLOSE	DO	080-I-0024	
	LCP-380-01	FV	380	501	03		380-501	FV-380-501-03-CLOSED	FV-380-501-03-CLOSED	ANIONIC POLYMER TANK 2 INLET VLV CLOSED	CLOSED	DI	080-I-0024	
	LCP-380-01	FV	380	501	03		380-501	FV-380-501-03-FAIL	FV-380-501-03-FAIL	ANIONIC POLYMER TANK 2 INLET VLV FAIL	FAIL	DI	080-I-0024	
	LCP-380-01	FV	380	501	03		380-501	FV-380-501-03-OPEN	FV-380-501-03-OPEN	ANIONIC POLYMER TANK 2 INLET VLV OPEN CMD	OPEN	DO	080-I-0024	
	LCP-380-01	FV	380	501	03		380-501	FV-380-501-03-OPENED	FV-380-501-03-OPENED	ANIONIC POLYMER TANK 2 INLET VLV OPENED	OPENED	DI	080-I-0024	
	LCP-380-01	FV	380	501	03		380-501	FV-380-501-03-REMOTE	FV-380-501-03-REMOTE	ANIONIC POLYMER TANK 2 INLET VLV IN REMOTE	REMOTE	DI	080-I-0024	
	LCP-380-01	FV	380	501	04		380-501	FV-380-501-04-CLOSE	FV-380-501-04-CLOSE	ANIONIC POLYMER TANK 2 DISCH VLV CLOSE CMD	CLOSE	DO	080-I-0024	
	LCP-380-01	FV	380	501	04		380-501	FV-380-501-04-CLOSED	FV-380-501-04-CLOSED	ANIONIC POLYMER TANK 2 DISCH VLV CLOSED	CLOSED	DI	080-I-0024	
	LCP-380-01	FV	380	501	04		380-501	FV-380-501-04-FAIL	FV-380-501-04-FAIL	ANIONIC POLYMER TANK 2 DISCH VLV FAIL	FAIL	DI	080-I-0024	
	LCP-380-01	FV	380	501	04		380-501	FV-380-501-04-OPEN	FV-380-501-04-OPEN	ANIONIC POLYMER TANK 2 DISCH VLV OPEN CMD	OPEN	DO	080-I-0024	
	LCP-380-01	FV	380	501	04		380-501	FV-380-501-04-OPENED	FV-380-501-04-OPENED	ANIONIC POLYMER TANK 2 DISCH VLV OPENED	OPENED	DI	080-I-0024	
	LCP-380-01	FV	380	501	04		380-501	FV-380-501-04-REMOTE	FV-380-501-04-REMOTE	ANIONIC POLYMER TANK 2 DISCH VLV IN REMOTE	REMOTE	DI	080-I-0024	
	LCP-380-01	LIT	380	200	01		380-200	LIT-380-200-01-LEVEL	LIT-380-200-01-LEVEL	FECL STORAGE TANK LEVEL	LEVEL	AI	080-I-0025	120vac
	LCP-380-01	FIT	380	201	01		380-201	FIT-380-201-01-FAIL	FIT-380-201-01-FAIL	FECL METERING PUMP 1 DISCHG FLOW FAIL	FAIL	DI	080-I-0025	
	LCP-380-01	FIT	380	201	01		380-201	FIT-380-201-01-FLOW	FIT-380-201-01-FLOW	FECL METERING PUMP 1 DISCHG FLOW	FLOW	AI	080-I-0025	120vac
	LCP-380-01	FIT	380	201	01		380-201	FIT-380-201-01-PULSE	FIT-380-201-01-PULSE	FECL METERING PUMP 1 DISCHG FLOW PULSE	PULSE	DI	080-I-0025	
	LCP-380-01	PMP	380	201	01		380-201	PMP-380-201-01-ALM	PMP-380-201-01-ALM	FECL METERING PUMP 1	ALM	DI	080-I-0025	
	LCP-380-01	PMP	380	201	01		380-201	PMP-380-201-01-PSH	PMP-380-201-01-PSH	FECL METERING PUMP 1 HIGH DISCHG PRESS	PSH	DI	080-I-0025	
	LCP-380-01	PMP	380	201	01		380-201	PMP-380-201-01-REMOTE	PMP-380-201-01-REMOTE	FECL METERING PUMP 1 IN REMOTE	REMOTE	DI	080-I-0025	

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CS/VFD	PANEL_NO	INST TYPE	FACILITY NUMBER	LOOP	NUMBER	TAG SUFFIX	LOOP_NO	IO_TAG	TAG_NO	LOOP_TITLE	I/O FUNCTION	IO_TYPE	P+ID NO	120vac
	LCP-380-01	PMP	380	201	01		380-201	PMP-380-201-01-RUNNING	PMP-380-201-01-RUNNING	FECL METERING PUMP 1 RUNNING	RUNNING	DI	080-I-0025	
	LCP-380-01	PMP	380	201	01		380-201	PMP-380-201-01-SC	PMP-380-201-01-SC	FECL METERING PUMP 1 SPD CMD	SC	AO	080-I-0025	
	LCP-380-01	PMP	380	201	01		380-201	PMP-380-201-01-START	PMP-380-201-01-START	FECL METERING PUMP 1 START	START	DO	080-I-0025	
	LCP-380-01	FIT	380	201	02		380-201	FIT-380-201-02-FAIL	FIT-380-201-02-FAIL	FECL METERING PUMP 2 DISCHG FLOW FAIL	FAIL	DI	080-I-0025	
	LCP-380-01	FIT	380	201	02		380-201	FIT-380-201-02-FLOW	FIT-380-201-02-FLOW	FECL METERING PUMP 2 DISCHG FLOW	FLOW	AI	080-I-0025	120vac
	LCP-380-01	FIT	380	201	02		380-201	FIT-380-201-02-PULSE	FIT-380-201-02-PULSE	FECL METERING PUMP 2 DISCHG FLOW PULSE	PULSE	DI	080-I-0025	
	LCP-380-01	PMP	380	201	02		380-201	PMP-380-201-02-ALM	PMP-380-201-02-ALM	FECL METERING PUMP 2	ALM	DI	080-I-0025	
	LCP-380-01	PMP	380	201	02		380-201	PMP-380-201-02-PSH	PMP-380-201-02-PSH	FECL METERING PUMP 2 FECL METERING PUMP 2 HIGH DISCHG PRESS	PSH	DI	080-I-0025	
	LCP-380-01	PMP	380	201	02		380-201	PMP-380-201-02-REMOTE	PMP-380-201-02-REMOTE	FECL METERING PUMP 2 IN REMOTE	REMOTE	DI	080-I-0025	
	LCP-380-01	PMP	380	201	02		380-201	PMP-380-201-02-RUNNING	PMP-380-201-02-RUNNING	FECL METERING PUMP 2 RUNNING	RUNNING	DI	080-I-0025	
	LCP-380-01	PMP	380	201	02		380-201	PMP-380-201-02-SC	PMP-380-201-02-SC	FECL METERING PUMP 2 SPD CMD	SC	AO	080-I-0025	
	LCP-380-01	PMP	380	201	02		380-201	PMP-380-201-02-START	PMP-380-201-02-START	FECL METERING PUMP 2 START	START	DO	080-I-0025	
	LCP-380-01	PMP	380	201	03		380-201	PMP-380-201-03-ALM	PMP-380-201-03-ALM	FECL METERING PUMP 3	ALM	DI	080-I-0025	
	LCP-380-01	PMP	380	201	03		380-201	PMP-380-201-03-PSH	PMP-380-201-03-PSH	FECL METERING PUMP 3 FECL METERING PUMP 2 HIGH DISCHG PRESS	PSH	DI	080-I-0025	
	LCP-380-01	PMP	380	201	03		380-201	PMP-380-201-03-REMOTE	PMP-380-201-03-REMOTE	FECL METERING PUMP 3 IN REMOTE	REMOTE	DI	080-I-0025	
	LCP-380-01	PMP	380	201	03		380-201	PMP-380-201-03-RUNNING	PMP-380-201-03-RUNNING	FECL METERING PUMP 3 RUNNING	RUNNING	DI	080-I-0025	
	LCP-380-01	PMP	380	201	03		380-201	PMP-380-201-03-SC	PMP-380-201-03-SC	FECL METERING PUMP 3 SPD CMD	SC	AO	080-I-0025	
	LCP-380-01	PMP	380	201	03		380-201	PMP-380-201-03-START	PMP-380-201-03-START	FECL METERING PUMP 3 START	START	DO	080-I-0025	
	LCP-380-01	FIT	380	601	03		380-601	FIT-380-601-03-FAIL	FIT-380-601-03-FAIL	ANIONIC POLYMER FEED PUMP 3 DISCHG FLOW FAIL	FAIL	DI	080-I-0026	
	LCP-380-01	FIT	380	601	03		380-601	FIT-380-601-03-FLOW	FIT-380-601-03-FLOW	ANIONIC POLYMER FEED PUMP 3 DISCHG FLOW	FLOW	AI	080-I-0026	120vac

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CS/VFD	PANEL_NO	INST TYPE	FACILITY NUMBER	LOOP	NUMBER	TAG SUFFIX	LOOP_NO	IO_TAG	TAG_NO	LOOP_TITLE	I/O FUNCTION	IO_TYPE	P+ID NO	120vac
	LCP-380-01	FIT	380	601	03		380-601	FIT-380-601-03-PULSE	FIT-380-601-03-PULSE	ANIONIC POLYMER FEED PUMP 3 DISCHG FLOW PULSE	PULSE	DI	080-I-0026	
	LCP-380-01	PMP	380	601	03		380-601	PMP-380-601-03-ALM	PMP-380-601-03-ALM	ANIONIC POLYMER FEED PUMP 3	ALM	DI	080-I-0026	
	LCP-380-01	PMP	380	601	03		380-601	PMP-380-601-03-PSH	PMP-380-601-03-PSH	ANIONIC POLYMER FEED PUMP 3 HIGH DISCHG PRESS	PSH	DI	080-I-0026	
	LCP-380-01	PMP	380	601	03		380-601	PMP-380-601-03-REMOTE	PMP-380-601-03-REMOTE	ANIONIC POLYMER FEED PUMP 3 IN REMOTE	REMOTE	DI	080-I-0026	
	LCP-380-01	PMP	380	601	03		380-601	PMP-380-601-03-RUNNING	PMP-380-601-03-RUNNING	ANIONIC POLYMER FEED PUMP 3 RUNNING	RUNNING	DI	080-I-0026	
	LCP-380-01	PMP	380	601	03		380-601	PMP-380-601-03-SC	PMP-380-601-03-SC	ANIONIC POLYMER FEED PUMP 3 SPD CMD	SC	AO	080-I-0026	
	LCP-380-01	PMP	380	601	03		380-601	PMP-380-601-03-START	PMP-380-601-03-START	ANIONIC POLYMER FEED PUMP 3 START	START	DO	080-I-0026	
	LCP-380-01	FIT	380	601	04		380-601	FIT-380-601-04-FAIL	FIT-380-601-04-FAIL	ANIONIC POLYMER FEED PUMP 4 DISCHG FLOW FAIL	FAIL	DI	080-I-0026	
	LCP-380-01	FIT	380	601	04		380-601	FIT-380-601-04-FLOW	FIT-380-601-04-FLOW	ANIONIC POLYMER FEED PUMP 4 DISCHG FLOW	FLOW	AI	080-I-0026	120vac
	LCP-380-01	FIT	380	601	04		380-601	FIT-380-601-04-PULSE	FIT-380-601-04-PULSE	ANIONIC POLYMER FEED PUMP 4 DISCHG FLOW PULSE	PULSE	DI	080-I-0026	
	LCP-380-01	PMP	380	601	04		380-601	PMP-380-601-04-ALM	PMP-380-601-04-ALM	ANIONIC POLYMER FEED PUMP 4	ALM	DI	080-I-0026	
	LCP-380-01	PMP	380	601	04		380-601	PMP-380-601-04-PSH	PMP-380-601-04-PSH	ANIONIC POLYMER FEED PUMP 4 HIGH DISCHG PRESS	PSH	DI	080-I-0026	
	LCP-380-01	PMP	380	601	04		380-601	PMP-380-601-04-REMOTE	PMP-380-601-04-REMOTE	ANIONIC POLYMER FEED PUMP 4 IN REMOTE	REMOTE	DI	080-I-0026	
	LCP-380-01	PMP	380	601	04		380-601	PMP-380-601-04-RUNNING	PMP-380-601-04-RUNNING	ANIONIC POLYMER FEED PUMP 4 RUNNING	RUNNING	DI	080-I-0026	
	LCP-380-01	PMP	380	601	04		380-601	PMP-380-601-04-SC	PMP-380-601-04-SC	ANIONIC POLYMER FEED PUMP 4 SPD CMD	SC	AO	080-I-0026	
	LCP-380-01	PMP	380	601	04		380-601	PMP-380-601-04-START	PMP-380-601-04-START	ANIONIC POLYMER FEED PUMP 4 START	START	DO	080-I-0026	
	LCP-380-01	PMP	380	601	05		380-601	PMP-380-601-05-ALM	PMP-380-601-05-ALM	ANIONIC POLYMER FEED PUMP 5	ALM	DI	080-I-0026	
	LCP-380-01	PMP	380	601	05		380-601	PMP-380-601-05-PSH	PMP-380-601-05-PSH	ANIONIC POLYMER FEED PUMP 5 HIGH DISCHG PRESS	PSH	DI	080-I-0026	
	LCP-380-01	PMP	380	601	05		380-601	PMP-380-601-05-REMOTE	PMP-380-601-05-REMOTE	ANIONIC POLYMER FEED PUMP 5 IN REMOTE	REMOTE	DI	080-I-0026	
	LCP-380-01	PMP	380	601	05		380-601	PMP-380-601-05-RUNNING	PMP-380-601-05-RUNNING	ANIONIC POLYMER FEED PUMP 5 RUNNING	RUNNING	DI	080-I-0026	
	LCP-380-01	PMP	380	601	05		380-601	PMP-380-601-05-SC	PMP-380-601-05-SC	ANIONIC POLYMER FEED PUMP 5 SPD CMD	SC	AO	080-I-0026	

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CS/VFD	PANEL_NO	INST TYPE	FACILITY NUMBER	LOOP	NUMBER	TAG SUFFIX	LOOP_NO	IO_TAG	TAG_NO	LOOP_TITLE	I/O FUNCTION	IO_TYPE	P+ID NO	120vac
	LCP-380-01	PMP	380	601	05		380-601	PMP-380-601-05-START	PMP-380-601-05-START	ANIONIC POLYMER FEED PUMP 5 START	START	DO	080-I-0026	
	LCP-380-01	WIT	380	700	01		380-700	WIT-380-700-01-LEVEL	WIT-380-700-01-LEVEL	PHOSPHORIC ACID TOTE LEVEL	LEVEL	AI	080-I-0027	120vac
	LCP-380-01	FIT	380	701	01		380-701	FIT-380-701-01-FAIL	FIT-380-701-01-FAIL	PHOSPHORIC ACID FEED PUMP 1 DISCHG FLOW FAIL	FAIL	DI	080-I-0027	
	LCP-380-01	FIT	380	701	01		380-701	FIT-380-701-01-FLOW	FIT-380-701-01-FLOW	PHOSPHORIC ACID FEED PUMP 1 DISCHG FLOW	FLOW	AI	080-I-0027	120vac
	LCP-380-01	FIT	380	701	01		380-701	FIT-380-701-01-PULSE	FIT-380-701-01-PULSE	PHOSPHORIC ACID FEED PUMP 1 DISCHG FLOW PULSE	PULSE	DI	080-I-0027	
	LCP-380-01	LSH	380	701	01		380-701	LSH-380-701-01-LSH	LSH-380-701-01-LSH	PHOSPHORIC ACID AREA SUMP HIGH LEVEL	LSH	DI	080-I-0027	
	LCP-380-01	PMP	380	701	01		380-701	PMP-380-701-01-ALM	PMP-380-701-01-ALM	PHOSPHORIC ACID FEED PUMP 1 ALARM	ALM	DI	080-I-0027	
	LCP-380-01	PMP	380	701	01		380-701	PMP-380-701-01-PSH	PMP-380-701-01-PSH	PHOSPHORIC ACID FEED PUMP 1 IN REMOTE	PSH	DI	080-I-0027	
	LCP-380-01	PMP	380	701	01		380-701	PMP-380-701-01-RUNNING	PMP-380-701-01-RUNNING	PHOSPHORIC ACID FEED PUMP 1 RUNNING	RUNNING	DI	080-I-0027	
	LCP-380-01	PMP	380	701	01		380-701	PMP-380-701-01-SC	PMP-380-701-01-SC	PHOSPHORIC ACID FEED PUMP 1 SPD CMD	SC	AO	080-I-0027	
	LCP-380-01	PMP	380	701	01		380-701	PMP-380-701-01-START	PMP-380-701-01-START	PHOSPHORIC ACID FEED PUMP 1 START	START	DO	080-I-0027	
	LCP-380-01	PSH	380	701	01		380-701	PSH-380-701-01-PSH	PSH-380-701-01-PSH	PHOSPHORIC ACID FEED PUMP 1 HI PRESS	PSH	DI	080-I-0027	
	LCP-380-01	PMP	380	701	02		380-701	PMP-380-701-02-ALM	PMP-380-701-02-ALM	PHOSPHORIC ACID FEED PUMP 2 ALARM	ALM	DI	080-I-0027	
	LCP-380-01	PMP	380	701	02		380-701	PMP-380-701-02-REMOTE	PMP-380-701-02-REMOTE	PHOSPHORIC ACID FEED PUMP 2 IN REMOTE	REMOTE	DI	080-I-0027	
	LCP-380-01	PMP	380	701	02		380-701	PMP-380-701-02-RUNNING	PMP-380-701-02-RUNNING	PHOSPHORIC ACID FEED PUMP 2 RUNNING	RUNNING	DI	080-I-0027	
	LCP-380-01	PMP	380	701	02		380-701	PMP-380-701-02-SC	PMP-380-701-02-SC	PHOSPHORIC ACID FEED PUMP 2 SPD CMD	SC	AO	080-I-0027	
	LCP-380-01	PMP	380	701	02		380-701	PMP-380-701-02-START	PMP-380-701-02-START	PHOSPHORIC ACID FEED PUMP 2 START	START	DO	080-I-0027	
	LCP-380-01	PSH	380	701	02		380-701	PSH-380-701-02-PSH	PSH-380-701-02-PSH	PHOSPHORIC ACID FEED PUMP 2 HI PRESS	PSH	DI	080-I-0027	
	LCP-300-01	LIT	300	800	01		300-800	LIT-300-800-01-LEVEL	LIT-300-800-01-LEVEL	CO2 TANK LEVEL	LEVEL	AI	080-I-0028	120vac
	LCP-300-01	PSH	300	800	01		300-800	PSH-300-800-01-PSH	PSH-300-800-01-PSH	CO2 TANK HI PRESS	PSH	DI	080-I-0028	
	LCP-300-01	PMP	300	801	01		300-801	PMP-300-801-01-FAIL	PMP-300-801-01-FAIL	SOLUTION FEED PANEL 1 FAIL	FAIL	DI	080-I-0028	

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CS/VFD	PANEL_NO	INST TYPE	FACILITY NUMBER	LOOP	NUMBER	TAG SUFFIX	LOOP_NO	IO_TAG	TAG_NO	LOOP_TITLE	I/O FUNCTION	IO_TYPE	P+ID NO	120vac
	LCP-300-01	PMP	300	801	01		300-801	PMP-300-801-01-RUNNING	PMP-300-801-01-RUNNING	SOLUTION FEED PANEL 1 RUNNING	RUNNING	DI	080-I-0028	
	LCP-300-01	PMP	300	801	01		300-801	PMP-300-801-01-START	PMP-300-801-01-START	SOLUTION FEED PANEL 1 START	START	DO	080-I-0028	
	LCP-380-01	LSH	380	901	01		380-901	LSH-380-901-01-LSH	LSH-380-901-01-LSH	BASIC AND POLYMER TRUCK UNLOADING CONTAINMENT SUMP PUMP HI LEVEL	LSH	DI	080-I-0029	
	LCP-380-01	LSHH	380	901	01		380-901	LSHH-380-901-01-LSH	LSHH-380-901-01-LSH	BASIC AND POLYMER TRUCK UNLOADING CONTAINMENT SUMP PUMP HI HI LEVEL	LSH	DI	080-I-0029	
	LCP-380-01	LSL	380	901	01		380-901	LSL-380-901-01-LSL	LSL-380-901-01-LSL	BASIC AND POLYMER TRUCK UNLOADING CONTAINMENT SUMP PUMP LO LEVEL	LSL	DI	080-I-0029	
	LCP-380-01	PMP	380	901	01		380-901	PMP-380-901-01-FAIL	PMP-380-901-01-FAIL	BASIC AND POLYMER TRUCK UNLOADING CONTAINMENT SUMP PUMP FAIL	FAIL	DI	080-I-0029	
	LCP-380-01	PMP	380	901	01		380-901	PMP-380-901-01-REMOTE	PMP-380-901-01-REMOTE	BASIC AND POLYMER TRUCK UNLOADING CONTAINMENT SUMP PUMP IN REMOTE	REMOTE	DI	080-I-0029	
	LCP-380-01	PMP	380	901	01		380-901	PMP-380-901-01-RUNNING	PMP-380-901-01-RUNNING	BASIC AND POLYMER TRUCK UNLOADING CONTAINMENT SUMP PUMP RUNNING	RUNNING	DI	080-I-0029	
	LCP-380-01	PMP	380	901	01		380-901	PMP-380-901-01-START	PMP-380-901-01-START	BASIC AND POLYMER TRUCK UNLOADING CONTAINMENT SUMP PUMP START	START	DO	080-I-0029	
	LCP-380-01	FIT	380	601	01		380-601	FIT-380-601-01-FAIL	FIT-380-601-01-FAIL	ANIONIC POLYMER FEED PUMP 1 DISCHG FLOW FAIL	FAIL	DI	080-I-0030	
	LCP-380-01	FIT	380	601	01		380-601	FIT-380-601-01-FLOW	FIT-380-601-01-FLOW	ANIONIC POLYMER FEED PUMP 1 DISCHG FLOW	FLOW	DI	080-I-0030	
	LCP-380-01	FIT	380	601	01		380-601	FIT-380-601-01-PULSE	FIT-380-601-01-PULSE	ANIONIC POLYMER FEED PUMP 1 DISCHG FLOW PULSE	PULSE	DI	080-I-0030	
	LCP-380-01	PMP	380	601	01		380-601	PMP-380-601-01-ALM	PMP-380-601-01-ALM	ANIONIC POLYMER FEED PUMP 1	ALM	DI	080-I-0030	
	LCP-380-01	PMP	380	601	01		380-601	PMP-380-601-01-REMOTE	PMP-380-601-01-REMOTE	ANIONIC POLYMER FEED PUMP 1 IN REMOTE	REMOTE	DI	080-I-0030	
	LCP-380-01	PMP	380	601	01		380-601	PMP-380-601-01-RUNNING	PMP-380-601-01-RUNNING	ANIONIC POLYMER FEED PUMP 1 RUNNING	RUNNING	DI	080-I-0030	
	LCP-380-01	PMP	380	601	01		380-601	PMP-380-601-01-START	PMP-380-601-01-START	ANIONIC POLYMER FEED PUMP 1 START	START	DO	080-I-0030	
	LCP-380-01	PMP	380	601	01		380-601	PMP-380-601-01-SC	PMP-380-601-01-SC	ANIONIC POLYMER FEED PUMP 1 SPD CMD	SC	AO	080-I-0030	

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CS/VFD	PANEL_NO	INST TYPE	FACILITY NUMBER	LOOP	NUMBER	TAG SUFFIX	LOOP_NO	IO_TAG	TAG_NO	LOOP_TITLE	I/O FUNCTION	IO_TYPE	P+ID NO	120vac
	LCP-380-01	FIT	380	601	02		380-601	FIT-380-601-02-FAIL	FIT-380-601-02-FAIL	ANIONIC POLYMER FEED PUMP 2 DISCHG FLOW FAIL	FAIL	DI	080-I-0030	
	LCP-380-01	FIT	380	601	02		380-601	FIT-380-601-02-FLOW	FIT-380-601-02-FLOW	ANIONIC POLYMER FEED PUMP 2 DISCHG FLOW	FLOW	DI	080-I-0030	
	LCP-380-01	FIT	380	601	02		380-601	FIT-380-601-02-PULSE	FIT-380-601-02-PULSE	ANIONIC POLYMER FEED PUMP 2 DISCHG FLOW PULSE	PULSE	DI	080-I-0030	
	LCP-380-01	PMP	380	601	02		380-601	PMP-380-601-02-ALM	PMP-380-601-02-ALM	ANIONIC POLYMER FEED PUMP 2	ALM	DI	080-I-0030	
	LCP-380-01	PMP	380	601	02		380-601	PMP-380-601-02-PSH	PMP-380-601-02-PSH	ANIONIC POLYMER FEED PUMP 2 HIGH DISCHG PRESS	PSH	DI	080-I-0030	
	LCP-380-01	PMP	380	601	02		380-601	PMP-380-601-02-REMOTE	PMP-380-601-02-REMOTE	ANIONIC POLYMER FEED PUMP 2 IN REMOTE	REMOTE	DI	080-I-0030	
	LCP-380-01	PMP	380	601	02		380-601	PMP-380-601-02-RUNNING	PMP-380-601-02-RUNNING	ANIONIC POLYMER FEED PUMP 2 RUNNING	RUNNING	DI	080-I-0030	
	LCP-380-01	PMP	380	601	02		380-601	PMP-380-601-02-START	PMP-380-601-02-START	ANIONIC POLYMER FEED PUMP 2 START	START	DO	080-I-0030	
	LCP-380-01	PMP	380	601	02		380-601	PMP-380-601-02-SC	PMP-380-601-02-SC	ANIONIC POLYMER FEED PUMP 2 SPD CMD	SC	AO	080-I-0030	
VFD	LCP-300-01	PMP	300	105	01		300-105	PMP-300-105-01-FAIL	PMP-300-105-01-FAIL	GAC SUPPLY PUMP 1 FAIL	FAIL	ET	080-I-0011	
VFD	LCP-300-01	PMP	300	105	01		300-105	PMP-300-105-01-REMOTE	PMP-300-105-01-REMOTE	GAC SUPPLY PUMP 1 REMOTE	REMOTE	ET	080-I-0011	
VFD	LCP-300-01	PMP	300	105	01		300-105	PMP-300-105-01-RUNNING	PMP-300-105-01-RUNNING	GAC SUPPLY PUMP 1 RUNNING	RUNNING	ET	080-I-0011	
VFD	LCP-300-01	PMP	300	105	01		300-105	PMP-300-105-01-SC	PMP-300-105-01-SC	GAC SUPPLY PUMP 1 SPD CMD	SC	ET	080-I-0011	
VFD	LCP-300-01	PMP	300	105	01		300-105	PMP-300-105-01-SI	PMP-300-105-01-SI	GAC SUPPLY PUMP 1 SPD SPEED	SI	ET	080-I-0011	
VFD	LCP-300-01	PMP	300	105	01		300-105	PMP-300-105-01-START	PMP-300-105-01-START	GAC SUPPLY PUMP 1 SPD START	START	ET	080-I-0011	
VFD	LCP-300-01	PMP	300	105	02		300-105	PMP-300-105-02-FAIL	PMP-300-105-02-FAIL	GAC SUPPLY PUMP 2 FAIL	FAIL	ET	080-I-0011	
VFD	LCP-300-01	PMP	300	105	02		300-105	PMP-300-105-02-REMOTE	PMP-300-105-02-REMOTE	GAC SUPPLY PUMP 2 REMOTE	REMOTE	ET	080-I-0011	
VFD	LCP-300-01	PMP	300	105	02		300-105	PMP-300-105-02-RUNNING	PMP-300-105-02-RUNNING	GAC SUPPLY PUMP 2 RUNNING	RUNNING	ET	080-I-0011	
VFD	LCP-300-01	PMP	300	105	02		300-105	PMP-300-105-02-SC	PMP-300-105-02-SC	GAC SUPPLY PUMP 2 SPD CMD	SC	ET	080-I-0011	
VFD	LCP-300-01	PMP	300	105	02		300-105	PMP-300-105-02-SI	PMP-300-105-02-SI	GAC SUPPLY PUMP 2 SPD SPEED	SI	ET	080-I-0011	
VFD	LCP-300-01	PMP	300	105	02		300-105	PMP-300-105-02-START	PMP-300-105-02-START	GAC SUPPLY PUMP 2 SPD START	START	ET	080-I-0011	

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CS/VFD	PANEL_NO	INST TYPE	FACILITY NUMBER	LOOP	NUMBER	TAG SUFFIX	LOOP_NO	IO_TAG	TAG_NO	LOOP_TITLE	I/O FUNCTION	IO_TYPE	P+ID NO	120vac
VFD	LCP-300-01	PMP	300	105	03		300-105	PMP-300-105-03-FAIL	PMP-300-105-03-FAIL	GAC SUPPLY PUMP 3 FAIL	FAIL	ET	080-I-0011	
VFD	LCP-300-01	PMP	300	105	03		300-105	PMP-300-105-03-REMOTE	PMP-300-105-03-REMOTE	GAC SUPPLY PUMP 3 REMOTE	REMOTE	ET	080-I-0011	
VFD	LCP-300-01	PMP	300	105	03		300-105	PMP-300-105-03-RUNNING	PMP-300-105-03-RUNNING	GAC SUPPLY PUMP 3 RUNNING	RUNNING	ET	080-I-0011	
VFD	LCP-300-01	PMP	300	105	03		300-105	PMP-300-105-03-SC	PMP-300-105-03-SC	GAC SUPPLY PUMP 3 SPD CMD	SC	ET	080-I-0011	
VFD	LCP-300-01	PMP	300	105	03		300-105	PMP-300-105-03-SI	PMP-300-105-03-SI	GAC SUPPLY PUMP 3 SPD SPEED	SI	ET	080-I-0011	
VFD	LCP-300-01	PMP	300	105	03		300-105	PMP-300-105-03-START	PMP-300-105-03-START	GAC SUPPLY PUMP 3 SPD START	START	ET	080-I-0011	
	LCP-380-01	LVL	380	101	10		380-101	LVL-380-101-10-LEVEL	LVL-380-101-10-LEVEL	S04 TRUCK UNLOADING PANEL LEVEL SIGNAL FROM SCADA	LEVEL	AO	080-I-0019	
	LCP-380-01	LVL	380	201	10		380-201	LVL-380-201-10-LEVEL	LVL-380-201-10-LEVEL	FECL TRUCK UNLOADING PANEL LEVEL SIGNAL FROM SCADA	LEVEL	AO	080-I-0020	
	LCP-380-01	LVL	380	301	10		380-301	LVL-380-301-10-LEVEL	LVL-380-301-10-LEVEL	SHC TRUCK UNLOADING PANEL LEVEL SIGNAL FROM SCADA	LEVEL	AO	080-I-0021	
	LCP-380-01	LVL	380	401	10		380-401	LVL-380-401-10-LEVEL	LVL-380-401-10-LEVEL	NAOH TRUCK UNLOADING PANEL LEVEL SIGNAL FROM SCADA	LEVEL	AO	080-I-0022	
	LCP-300-01	LVL	380	801	10		380-801	LVL-380-801-10-LEVEL	LVL-380-801-10-LEVEL	CO2 TRUCK UNLOADING PANEL LEVEL SIGNAL FROM SCADA	LEVEL	AO	080-I-0028	
	LCP-380-01	HRN	380	101	10		380-101	HRN-380-101-10-HRN	HRN-380-101-10-HRN	S04 TRUCK UNLOADING PANEL HORN/BEACON	HRN	DO	080-I-0019	
	LCP-380-01	HRN	380	201	10		380-201	HRN-380-201-10-HRN	HRN-380-201-10-HRN	FECL TRUCK UNLOADING PANEL HORN/BEACON	HRN	DO	080-I-0020	
	LCP-380-01	HRN	380	301	10		380-301	HRN-380-301-10-HRN	HRN-380-301-10-HRN	SHC TRUCK UNLOADING PANEL HORN/BEACON	HRN	DO	080-I-0021	
	LCP-380-01	HRN	380	401	10		380-401	HRN-380-401-10-HRN	HRN-380-401-10-HRN	NAOH TRUCK UNLOADING PANEL HORN/BEACON	HRN	DO	080-I-0022	
	LCP-300-01	HRN	380	801	10		380-801	HRN-380-801-10-HRN	HRN-380-801-10-HRN	CO2 TRUCK UNLOADING PANEL HORN/BEACON	HRN	DO	080-I-0028	
		AIT	900	100	01		900-100	AIT-900-100-01-CL2	AIT-900-100-01-CL2	TANK T3 RESIDUAL CL2	CL2	AI	080-I-0030	120vac
		AIT	900	100	02		900-100	AIT-900-100-02-CL2	AIT-900-100-02-CL2	TANK T3 RESIDUAL CL2	CL2	AI	080-I-0030	120vac

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SECTION 40 94 13
DIGITAL PROCESS CONTROL COMPUTERS

PART 1 GENERAL

1.01 SUMMARY

A. This section covers requirements for Computer Subsystem (CS) and is in addition to requirements in Section 40 90 00, Instrumentation and Control for Process Systems. Key technical definitions and requirements for CS are given in Section 40 90 00, Instrumentation and Control for Process Systems.

B. CS functions include data acquisition, historical data storage, text and graphic data display, alarming, process control, data analysis, report generation, and program development. Requirements listed identify minimum acceptable system performance. Provide all hardware and software features required to make system totally operational, with convenient operator interface and efficient equipment use.

C. Configuring of applications software will be provided by Engineer.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. Institute of Electrical and Electronics Engineers (IEEE): 802.3, Local Area Networks: Carrier Sense Multiple Access with Collision Detection
2. International Organization for Standardization (ISO): 7185, Programming Languages - PASCAL (Endorsement of British Standard BS 6192).
3. International Society of Automation (ISA): 5.5, Graphic Symbols for Process Displays.

1.03 DEFINITIONS

A. Abbreviations:

1. CPU: Central Processing Unit.
2. CS: Computer Subsystem.
3. DCS: Distributed Control Subsystem.
4. DCU: Distributed Control Unit.
5. PLC: Programmable Logic Controller.
6. PMCS: Process Monitoring and Control Software.
7. RTU: Remote Terminal Unit.
8. TS: Telemetry Subsystem.

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B. Terms:

1. Circular Files: Files that are updated such that each record written to file replaces oldest record in file.
2. Log a Message: Print a message on an alarm/status printer.
3. Field Interface Units: **[A: PLCs.] [B: RTUs.] [C: DCUs.]** If PLCs are used as RTUs, then requirements for PLCs also apply to RTUs.

C. Types of Variables:

1. Field Interface Unit Variables: Analog inputs, discrete inputs, analog outputs, discrete outputs, pulse inputs, calculated variables, and internal register values.
2. Calculated Analog Points (CA): Analog variables computed from inputs from field interface units, manual inputs, calculated discrete points, and other calculated analog points.
3. Calculated Discrete Points (CD): Discrete variables computed from inputs from field interface units, manual inputs, calculates analog points, and other calculated discrete points.
4. Manual Inputs (MI): Variables whose values are manually entered (for example, laboratory data).
5. Process Variables (PV): Analog variables from field interface units and calculated analog points.

1.04 SUBMITTALS

A. Action Submittals:

1. CS block diagram and overview description.
2. Bill of Materials for CS Components: Component number, manufacturer, model number, component description, and quantity.
3. Room Layout Drawings: For show to scale enclosures, furniture, CS equipment, and service area requirements.
4. Power Connection Diagram: For CS equipment in show interconnection from power sources through uninterruptible power supplies and power distribution panels, to computer and peripherals.
5. Grounding Diagram: For CS equipment show grounding philosophy and implementation.
6. Interconnecting Wiring and Cabling Diagrams: For CS equipment, identify terminal receptacles, cable ID tags, actual cable lengths, and maximum distance limitations between cabinets or components.
7. Component Submittal:
    a. For Each CS Component:
        1) General data and description.
        2) Engineering Specifications and data sheets.
        3) Scaled drawings and mounting arrangements.

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4) Equipment weights.
5) Power and grounding requirements.
6) External electrical interconnection and interface definitions.

8. Shop Drawings for Specifically Manufactured CS Equipment:
   a. A complete connection diagram.
   b. Data sheets on each major item, annotated as necessary to describe specific items furnished.
   c. Scaled Layout and Fabrication Drawings:
      1) Cable access areas and cable routing.
      2) Power termination and ground lug location.
      3) Data cable termination points.
      4) Anchor bolt size and location.
   d. Installation and mounting detail drawings.
   e. Equipment weights.
9. Power Consumption and Heat Dissipation Summary for CS Equipment: Voltages, current, phase(s), and maximum heat dissipations in Btu/hr.

B. Software:

1. Standard Software Documentation:
   a. System Software Documentation: Complete reference information for system users. Detailed descriptions including features and limitations of package, how to use package, and how package interfaces with other software packages.
      1) Extended Documentation for Operating System and Utilities:
         a) Base Documentation: For day-to-day users of tasks, including editing files and using command procedures.
         b) General User Documentation:
            (1) Index to Extended Documentation.
            (2) Using files, directories, command language, and text editors.
            (3) Alphabetic list of errors, warning, and informational messages, including explanation and response required.
         c) System Manager Documentation:
            (1) Setting up systems.
            (2) Maintaining system and files.
            (3) Optimizing performance.
            (4) Networking features.
         d) Programming Documentation:
            (1) Linking, loading, running, and debugging tasks.
            (2) Screen management.

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(3) Librarian and file management.
(4) Device support and device drivers.
e) Release notes.
2) Programming Language: Syntax, execution, use and reference capabilities.
3) Online and Offline Diagnostics: How they are used, and various execution options available.

b. PMCS: Detailed technical reference manuals and user level manuals.
1) Types of Manuals:
a) System Manager Documentation:
(1) Initial system setup.
(2) Database and file structures.
(3) Communication with field interface units.
(4) Maintaining system and files.
(5) Troubleshooting system problems.
(6) Optimizing performance.
b) System Engineer Documentation: Configuring, applications software.
c) Operator Documentation: Using the PMCS with configured applications software.
2) PMCS Functions:
a) Process database.
b) Communication with field devices.
c) Calculated analog points and calculated discrete points.
d) Input processing.
e) Message logging.
f) CS diagnostic alarms.
g) Alarm handling.
h) Control processor.
i) Restart program.
j) Man-machine interface-general functions.
k) Graphics display generator.
l) Types of displays.
m) Alarm/Status log history.
n) Historical data collection.
o) Data retrieval.
p) Trending.
q) Report generator.

c. Disk and Memory Requirements: Table showing CPU and disk memory requirements for each standard software package.

d. Typical Examples from Previous Projects: Process graphic displays, historical trend displays, and alarm/status printer output.

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e. Changes to Standard Software: If changes to standard software packages are needed to meet Specifications, provide detailed descriptions of proposed changes and additions.
f. Presoftware Development Submittal: Software System Overview: Written overview description of each major software package.
g. Applications Software Implementation Standards: Standards and procedures to be used by persons developing, programming, configuring, and testing all software.
h. Applications Software: Outline of applications software to be developed. List programming language or configuration method to be used for each different type of application.
i. CRT Display Format Examples:
    1) Two typical examples for types required for CRT display that are not shown in standard software user's manuals.
    2) Typical process graphic displays and historical trend plots used on previous projects.
j. Report Formats: For each report required for this Project:
    1) Name of program used to configure report.
    2) Page number references to user's manual(s) that describe these programs.
    3) Examples of typical reports provided on other projects.
k. Alarm/Status Printer Format: Examples of alarm/status printer output formats used on previous projects.
l. Disk and Memory Allocations: Tables showing breakdown of relative percentages of CPU and disk memory required, including spare.
m. Historical Trend Display Format Examples:
    1) Short-term trends (less than 24 hours).
    2) Long-term trends (several days and several months).
n. Software Design Submittal: Detailed applications software documentation. Updated version of Presoftware Development Submittal. For standard software documentation, submit changes that have occurred to manuals since previous Submittal. Clearly indicate which pages are to be removed or replaced.
    1) Process Graphic Displays: Two-step submittal. Following Display Coordination Meeting, provide full set of process graphic displays.
        a) Step One: Preliminary versions of all displays. Hand drawn displays permitted at this step.
        b) Step Two: Machine-generated color copies of displays.
o. Process Graphic Displays: Full set of machine-generated color copies based on preliminary displays provided by Engineer.
p. Tabular Process Displays: Full set.

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q. Trend Displays Examples: Typical trend displays for short-term trends (less than 24 hours) and long-term trends (several days and several months).

r. Reports: Two-step Submittal.
   1) Step One: Full set of report layouts. Hand drawn displays or copies permitted at this step.
   2) Step Two: Full set of machine-generated reports.
      a) All pages for multiple page reports.
      b) Examples for different time periods (i.e., daily, monthly, yearly) where applicable.
      c) Formatted and well commented listings of report configuration data.

s. Database Configuration: Configuration data for:
   1) Process database.
   2) Historical database.
   3) I/O list.
   4) Calculated Analog and Discrete Points: Format similar to lists in these documents. Include description of algorithms used to compute each variable.
   5) Control Strategies: Detailed written descriptions and P&ID type diagrams depiction of control function.
   6) Any other process related databases.

t. Standard Software Changes and Additions: For programming required to augment Standard Software.
   1) Detailed written descriptions, block diagrams, and macro level flow charts or pseudo code.
   2) Pseudo code conforming to software implementation standards in Presoftware Development Submittal.

u. Disk Directory: File name, directory/path, file usage, and size.

v. Data Files Description: For each data file, list file name, purpose of file, size, and format of each record.

w. Description of other data structures used by CS.

x. System Management Plan: Recommendations for how Owner handles:
   1) System Log: Format and examples for recording computer operations related activities such as software problem, hardware problem, software changes, power failures, and disk backup/reload.
   2) Disk Backup: Backup frequency, number of backup copies, and storage of backup copies.

y. Preliminary Software Documentation: Fully detailed version of items described in paragraph O&M Manuals, Software Documentation.

z. Term “preliminary” refers only to timing of Submittal, not to level of detail to be provided.

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aa. Disk or magnetic tape copies required for final software documentation are not required for Preliminary Software Documentation.

C. Samples: Color and material Samples of hardware enclosures and furniture.

D. Informational Submittals:

1. Testing related Submittals.
2. O&M Manuals-Hardware:
   a. Updated version of Hardware Shop Drawings Submittals.
   b. Component Manufacturers' O&M Manuals: Instructions for installation, operation, maintenance, troubleshooting, and calibration.
   c. List of spare parts and expendables provided.
   d. List of recommended additional spare parts.
3. O&M Manuals-Software Documentation:
   a. Updated version of Software Shop Drawing Submittals.
   b. Initial values for database parameters–PMCS Error List:
      1) An alphabetical listing of all error, warning, and alarm messages logged by PMCS, except for process alarms.
      2) For each message, list message, description of condition, brief description of operator action required, and reference to manual covering condition.
   c. Complete systems generation data.
   d. Fully commented program listings for high level language programs created for this Project.
   e. System Programmer Operating Instructions: System operating procedures including system generation, system loading, and startup.
   f. System Operator Instructions: Computer operations procedures including system restarts, power failure and recovery, report generation, disk backup and reload, manual data entry, plot generation, historical tape operations, and general troubleshooting.
   g. Process Operator Instructions: Operator oriented procedures for operators CRTs, printers, and video copiers.
   h. Applications Software Source Files: One copy of fully commented source listings and source configuration data on disk and two copies on tape.
   i. Third Party Software: For system software that is not a product of the Contractor or his Subcontractors, include manufacturer's original disks and manuals with hardware shipments.

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1.05 ENVIRONMENTAL REQUIREMENTS

A. Central Control Room: Computer room, air conditioned.

B. Liquids and Solids Control Rooms: Inside, air conditioned.

C. Other Locations: Inside.

1.06 MAINTENANCE

A. Maintenance Service Agreement: Following Final Payment and Acceptance.

1. Onsite Software Consultant: Support in addition to that required by service agreement.
   a. Duration: **[A: 2 years.] [B: 1 year.]**
   b. Person-Days of Onsite Service: **[C: 30,] [D: 15,]** minimum. Provided on a demand basis.
   c. Visits to Plant Site: **[E: 10,] [F: 5,]** minimum.
   d. Support by programmer thoroughly familiar with CS.
   e. Services: Database, display, and report configuration; changes to standard software; optimization of CS operation; and training in addition to that specified under Article Training.
2. Service Agreement:
   a. Duration: **[G: 2 years.] [H: 1 year.]**
   b. Services: Manufacturer's recommended preventive maintenance, check system error counters, and install required engineering changes.
   c. Items Excluded: **[I:__printers.] [J:__Personal computers.]**
3. Telephone Support Service:
   a. Duration: **[K: 2 years.] [L: 1 year.]**
   b. Available during normal business week.
   c. Provided by persons thoroughly familiar with CS supplied.
4. Subscription to Software Update Service:
   a. Duration: **[M: 2 years.] [N: 1 year.]**
   b. Coverage: Standard software, including both system software and PMCS.
   c. Include new software versions, documentation updates, newsletters, software performance reports, and interim software updates.
5. Supplemental Training:
   a. Duration: **[O: 2] [P:]** instructor weeks.
   b. Content: Refresher on CS hardware maintenance. Cover installation, startup, diagnosis, and repair problems that Owner's staff has encountered in first 6 months of operation.

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1.07 EXTRA MATERIALS

A. Spare Parts:

1. Two track balls of each type supplied.
2. One complete Operator CRT unit.
3. One keyboard of each type used for Operator CRT units.
4. Modems: 20 percent, rounded up to nearest integer, for each type of modem supplied.

B. Expendables:

1. Two boxes (2,500 sheets per box) of single-part, 20-pound, unlined, white, tractor feed, edge perf, full width, fanfold paper for each impact printer, except for alarm/status printers.
2. Two boxes (1,500 sheets per box) of two-part, carbonless, 15-pound, green bar, tractor feed, edge perf, full width, fanfold paper for each alarm/status printer.
3. Two boxes (10 reams, 5,000 sheets per box), 20-pound, white paper for each laser printer.
4. Six ribbons for each impact printer.
5. Six ink cartridges for each noncolor inkjet printer.
6. Four sets of color ink cartridges for each color printer.
7. One toner cartridge kit and one user maintenance kit for laser printer.
8. Ten tape cartridges for computer using tape cartridges, including personal computers.
9. Fifty floppy diskettes for each computer using diskettes, including personal computers.
10. 20 percent, but no less than **[A: 10] [B:]** of each type and current rating of fuse used.

PART 2 PRODUCTS

2.01 SYSTEM PERFORMANCE

A. Capacity:

1. Furnish CS with sufficient capacity to handle equipment required by Contract Documents and equipment listed under paragraph Future Components, and still have specified spare capacity. Except for software configuring, implementing listed future components, shall not require addition of other CS hardware or software.
2. Spare capacities are based on size of CS as required to implement equipment required by Contract Documents plus equipment listed under paragraph Future Components. For example, total storage capacity furnished for given functions:

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(CURRENT + FUTURE)*(100 + SPARE)/100

Where:

CURRENT Equals: Storage capacity required to implement that function for hardware and software furnished under Contract Documents.

FUTURE Equals: Storage capacity required to implement that function for equipment listed under paragraph Future Components.

SPARE Equals: Percentage spare specified for that function.

3. Capacity refers to required physical size, storage capacity, and processing throughput of CS hardware and software. CS changes required to implement listed future components shall be limited to "configuring" database tables and system parameters to allow system to recognize the additional equipment.
4. In order to verify that system has required capacity, accelerate **[A: RTU] [B: PLC] [C: DCU]** polling rate and exception reporting rates during all tests to simulate inputs from additional devices listed under paragraph Future Components. For example, if number of future RTUs listed equals the number of RTUs required by contract document, conduct tests using a polling rate that is twice that specified.

B. Future Components: Furnish sufficient CS capacity to implement the following future components. Assume that each future field interface unit has a number of I/O points equal to average number of I/O point provided for similar units required by Contract Documents.

1. PLCs: **[A: .]**
2. RTUs (Large): **[B: .]**
3. RTUs (Medium): **[C: .]**
4. RTUs (Small): **[D: .]**
5. RTUs (Micro): **[E: .]**
6. DCS and DCUs: **[F: .]**
7. CS Operator CRTs: **[G: .]**

C. Operator CRT Response Time:

1. Under moderately busy conditions, displays on operator CRTs are brought up and updated with real-time data within number of seconds shown.

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Display Type	Bring Up	Update
Main Menu	4	--
Help & Legend	5	--
Process Graphic	7	10
Alarm Summary	6	--
Trend, Real-Time, 4 Points	5	5
Trend, 6-Hour, 5-Minute Samples, 4 Points	10	--
Trend, 5-Day, 1-Hour Samples, 4 Points	12	--
Tabular		10

2. Moderately busy conditions are defined as follows:
   a. Half the operator CRTs are each alternately requesting process graphic displays and historical trend displays.
   b. One operator CRT configuring process database.
   c. Daily report running.
   d. Data being transferred from process computer to personal computer.
   e. Field interface units are in operation.
   f. Analog and discrete input points requiring processing due to exception reports from field interface units occur at average rate of **[A: 10] [B: 50] [C:]** per second.
   g. Polling rates have been adjusted to simulate devices listed under paragraph Future Components.

D. End-to-End Response Time: Under moderately busy conditions, maximum time from beginning to end of following sequence shall be 10 seconds:

1. An operator initiates a request from a process graphic display to move a valve, start a drive, or stop a drive.
2. Command is sent to field interface unit.
3. Command is executed by field interface unit.
4. CS interrogates status of field interface unit.
5. CS updates process graphic display to show response to the command.

E. Dual Computer-Automatic Failover:

1. Response to Single Failure: No loss of required functions due to single failure of centrally located CS equipment or software.
2. CS Hardware Configuration: Refer to Control System Block Diagram on Drawings.

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3. Modes of Operation:
    a. Operator selection of either CPU as online CPU and other as hot-standby CPU. Provide for changing the status of the hot-standby computer to stand alone to operate independent of online computer.
    b. Hot-standby CPU request online CPU to report its status at least every 5 seconds. If online CPU does not respond properly for 10 seconds, hot-standby CPU takes control of online peripherals and field interface units and logs a failover message. Failed CPU then operate independent of online CPU until an operator requests failed system to return to hot-standby mode.
4. Online CPU periodically check status of hot-standby CPU and log alarm message if hot-standby CPU fails.
5. Maintain all data structures on the hot-standby CPU such that:
    a. For Process Database, related configuration tables and other data structures needed to fully define all real-time functions: Within 1 minute of time that changes to these data structures occur in online CPU, update hot-standby CPU with these changes.
    b. For historical disk files and all data structures and disk files not covered in above subparagraph: Within 15 minutes of time that changes to these data structures occur in online CPU, update hot-standby CPU with these changes.

2.02 SYSTEM SOFTWARE

A. Operating System: General-purpose, multiuser, multiprocessing operating system:

1. Multiprocessing support for simultaneous execution of process monitoring and control software tasks and system support tasks.
2. Multistream batch processing operating under control of indirect command files.
3. Priority task scheduler with provisions for job initiation on time of day, elapsed time, hardware interrupt, process event, request from another task, or operator request.
4. Schedule I/O operations on a priority basis with all I/O carried out concurrently with program execution.
5. Spooling (disk storage buffering) of all low speed printing devices.
6. Device independent input/output system using online reassignable logical unit numbers for peripheral devices and file names for disk and tape files.
7. Ability to delete, replace, or add process control tasks or system support while online.
8. Multilevel password protection scheme to control access to different system support tasks and disk based data structures.

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9. Systems Generation: Allow configuring of an operating system to meet specific requirements of hardware and software configuration.

B. Programming Languages:

1. Assembler: Symbolic language translator for converting macro assembly language source programs into relocatable object modules.
2. **[A: C Compiler.] [B: BASIC.] [C: PASCAL, conforming to ISO 7185.]**
    a. Subroutines for access to process database parameters.
    b. Subroutines for point-to-point line drawings, plot generation from X and Y data arrays, automatic scaling, and text annotation.
3. Provide compilers for languages in which PMCS package is written.

C. Utilities:

1. File Management:
    a. General-purpose file system supporting dynamic creation, extension, and deletion of disk files from source programs, object programs, and data files.
    b. Maintain on each disk a complete file directory including file name, size, location, and type.
    c. Automatic location on disk of new disk files.
    d. File protection for online disk file to prevent accidental modification.
    e. Copy individual files between devices (e.g., disk to disk, disk to tape, tape to disk, and disk to printer).
2. Text Editor: General-purpose, full screen text editor program for editing of source and data files on disk.
    a. Creating new files, add/delete/modify records, listing files, and so forth.
    b. Character string search, move, copy, and replacement functions.
3. Network Communications: General-purpose network communications software to support local area network connection between CS CPUs and personal computers. Allows for exchange of disk files between computer systems.
4. Debugging Aids: Online and offline debugging aids for high and low level language environments.
5. System Performance Monitor: Accumulate information on CS status and display summary on CRT. Monitor loading of CPUs, disks, and other peripheral devices.
6. Disk Backup and Reload: Operator-initiated utility for maintaining backup copy on **[A: tape] [B: removable disk pack]** of all CS disk files. Floppy diskettes not acceptable for backup.

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D. Diagnostics:

1. Online Diagnostics:
    a. Complete system of diagnostic software to monitor, isolate, identify, tabulate, and alarm system hardware malfunctions and software failures.
        1) Input/output addressing for all I/O devices (detection of illegal addresses).
        2) Incorrect data transfers (e.g., parity error).
        3) No response (or time-out) from I/O device.
    b. Central mechanism for accumulating and reporting number of soft and hard system errors. Hard errors are errors that persist after multiple retries.
2. Offline Diagnostics: Exercise and identify problems for all CS equipment.

2.03 PROCESS MONITORING AND CONTROL SOFTWARE (PMCS) PACKAGE

A. Configurable Software:

1. Allows online, interactive, menu driven configuring of applications software.
2. Concurrent operation of configuring functions and process monitoring and control functions.
3. Function Blocks:
    a. Used to implement data acquisition and control features.
    b. Have fill-in-the-blanks menu which show current status of all parameters associated with a given block.
    c. Unmodified parameters automatically assigned default values. Default values configurable by user.
    d. Can be linked together to form control loops.

B. Process Database:

1. Types of Database Points:
    a. I/O points from field interface devices.
    b. **[A: PCS Registers.] [B: DCS Database value.]** Allow for both integer and floating point values.
    c. CS calculated analog and calculated discrete points.
    d. CS manual inputs.
2. Database Fields:
    a. Tag numbers (minimum of 9 characters).
    b. Function block/point descriptions (minimum of 40 characters).
    c. Most recent value read.
    d. Process I/O hardware addresses.
    e. Scan rate.

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f. Scan enable/disable status.
g. Engineering units scale conversion factors.
h. Digital filter constants.
i. Data quality indicators.
j. Engineering units.
k. Alarm enable/disable status.
l. Alarm limits.
m. Status change log enable/disable status.
n. Timer settings.
o. Control tuning parameters.
p. Control status parameters.
q. Process I/O point value.
r. Historical data save requirements.
s. Real-time trend definitions.
t. Historical trend group definitions.

3. Documentation: Provide a means for obtaining hard-copy printout of configuration data for process database and function blocks.

C. **[A: CS/PLC] [B: CS/DCS]** Communications:

1. Periodically read discrete and analog inputs and outputs for each **[C: PLC] [D: DCS].**
2. On demand, read or load **[E: internal PLC registers] [F: DCS database value]** including individual timers, counters, timer/counter preset values, control loop setpoints, high/low limits, computed variables, control loop tuning constants, status indicators, and sequence START/STOP commands.
3. Refer to **[G: Section 40 90 01, Instrumentation and Control for Process Systems,] [H: Section 40 94 23, Distributed Process Control System,]** for additional requirements.

D. CS/TS Communications:

1. Scan Control: ON-SCAN/OFF-SCAN status selection for each RTU. Periodically poll all ON-SCAN RTUs.
2. Polling Rate: Individually adjustable for each RTU from 10 seconds to 15 minutes, with minimum resolution of 10 seconds.
3. Parallel Channels: Simultaneous scanning of different RTUs on different communication channels.
4. Error Detection and Correction:
   a. When communication errors are detected or an RTU fails to respond to a command, provide for adjustable number of retries for each RTU.
   b. If after retries, there has not been a successful communications, log an alarm message.

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c. Unless failed RTU is manually taken OFF-SCAN, periodically check to see if RTU is operational.

5. Types of Scans:
   a. Exception Report: Normal polling.
      1) Discrete input points that have changed state since last scan and analog input points that have changed by more than preset dead band since last read.
      2) Download dead band to each RTU.
   b. Full Report: Status on all I/O points. Request a full report for all RTUs at preset time interval. Request a full report when RTU is initially placed ON-SCAN.
6. Refer to Section 40 95 60, Telemetry System, for additional requirements.

E. Calculated Analog Points and Calculated Discrete Points:

1. Calculated on a real-time basis using configurable, BASIC like equations.
   a. Independent Variables: Analog inputs, discrete inputs, calculated analog points, calculated discrete points, and manual inputs.
   b. Arithmetic Operators: +, -, *, /, and exponentiation.
   c. Boolean Operators: AND, OR, XOR, and NOT.
   d. Relational Operators: LT, LE, EQ, NE, GE, and GT.
   e. Arithmetic Functions: SQRT, LOG, LOG10, EXP, SIN, COS, TAN, MIN, and MAX.
2. Have same functions as analog inputs and discrete inputs. For example, alarm logging, CRT displays, flow integrations, data collection, data retrieval, and trending functions.

F. Input Processing: All functions configurable on a per point basis.

1. Analog Points:
   a. First order exponential digital filtering or by field interface units with filter factors downloaded from CS.
   b. Instrument Failure Detection: Analog input variable not in 4 to 20 mA dc range. Set data quality to indicate “bad” data. If field interface unit provides detection, then field interface unit notifies CS of instrument failure conditions.
   c. Conversion to Engineering Units: Linear, square root, and polynomial conversions.
   d. LOW LOW, LOW, HIGH, HIGH HIGH process variable alarm checking. Dead bands individually adjustable for each point.
   e. Rate-of-change alarm checking.
   f. Pulse Inputs: Convert pulse rate to engineering units by dividing pulse count by time interval since last reading.
   g. Accumulate pulses in six-digit, minimum, pulse counters.

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2. Discrete Points:
    a. Alarms: Selectable alarm on high, low, or change of state.
    b. Inversion: Selectable inversion of input state.
    c. Status Change Logging: Option for status change logging to be activated or deactivated. When activated for a given point, print a status change message on alarm/status printer when point changes state.
    d. Elapsed Run Time Monitoring:
        1) Counter Size: Six digits, minimum.
        2) Counter Resolution: 0.1 hours, minimum.
    e. Cycle Counters: Counts changes from OFF-state to ON-state.
        1) Counting done by CS, or by field interface units with counts sent to CS.
        2) Counter Size: Six digits, minimum.
3. Provide a method for inhibiting updating of an input. Allow manual entry of values for testing purposes or for temporary use when input signal is in error. Set data quality indicator for manually entered values to indicate “inserted” value.

G. Message Logging: For all alarm, status change, parameter change, and event messages directed to alarm/status printers:

1. Messages Format:
    a. Time of occurrence in 24-hour format (HH:MM:SS).
    b. Operator CRT identification and user’s initials (for messages produced by an operator action).
    c. Message type. (i.e., alarm, status, parameter change, event, etc.)
    d. Facility tag. Component tag number or device number.
    e. Description of device or parameter.
    f. Description of condition.
    g. Process variable or parameter current value (if any).
    h. Process variable or parameter units (if any).
    i. Process variable alarm limit (for alarm messages).
2. Examples: Refer to Article Supplements, Example Alarm/Status Message Formats.
3. Every hour or once per page log message giving day, month, and year.
4. Buffer messages if generated faster than printer can print them.

H. CS Diagnostic Alarms: Log an alarm message if hardware or software errors, which might affect process monitoring and control functions, are detected by online diagnostics.

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I. Alarm Handling: Configure alarm handling as follows:

1. Alarm Sequence:
   a. When CS detects alarm condition on enabled point, log “Alarm” message, display alarm message in alarm window of each operator CRT, and actuate audio alarm at operator CRT.
   b. Continue audio alarm until alarm condition is acknowledged by entry from operator CRT.
   c. Log “Alarm Acknowledged” message when alarm is acknowledged.
   d. Log “Clear” message when alarm condition clears.
2. Alarm Acknowledge: For an alarm to be acknowledged, the alarm condition shall be visible on CRT display. Allow acknowledgement from Alarm Summary Display.

Summary of Alarm Requirements (RTN = Return to Normal)

Point Alarm Status	Alarm Acknowledged	Audio Alarm	Symbol & Message Color	Blink Alarm Message	On Alarm Summary Display
Alarm	No	Yes	Alarm	Yes	Yes
Alarm	Yes	No	Alarm	No	Yes
RTN	No	No	Normal	Yes	Yes
RTN	Yes	No	Normal	No	No

3. Disable Alarm Processing:
   a. Selectable by operator on point-by-point basis.
   b. Does not prevent point status from being shown on graphic process displays.
4. Alarm Destination: Configurable.

J. Control Processor:

1. Allow online configuring from operator CRT of control functions without use of computer programming language.
2. Controls configured by interconnecting software function blocks. Blocks configurable by entering specific values or connection specifications for individual block parameters. Unmodified parameters take on configured default values.
3. Function blocks and their associated parameters displayable on operator CRT.
4. Documentation: Hard-copy printout of configured database.
5. Continuous Control Functions:
   a. PID control.
   b. Manual loading station.

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c. Ratio control.
d. Cascade control.
e. Totalization.
f. Add/subtract/multiply/divide.
g. Square root.
h. Ramp control.
i. Function generation.
j. Minimum/maximum value select.
k. Signal limiter.
l. High/low signal selector.
m. Signal limit switch.
n. Signal deviation switch.
o. Lead/lag filter.
p. Noise filter.
q. Dead time simulation/compensation.
r. Moving averages.

6. Sequential Control Functions:
   a. Boolean Functions: AND, OR, XOR, and NOT.
   b. Timers: ON delay, OFF delay, and INTERVAL.
   c. Counters: Predetermining and totalizing.
   d. Signal selectors.
   e. Drum programmers.
   f. Alternators, or SET/RESET “flip-flop” elements.
   g. Sequencer:
      1) Configurable number of discrete control steps, 8 minimum.
      2) Configurable set of discrete control and logic outputs at each step, 8 minimum.
      3) Configurable set of discrete inputs at each step, 6 minimum.
      4) Test function of inputs at each step to initiate advancement to next step.
      5) A means to manually advance through each step.
      6) Set error indicator if at any step in a sequence a control device fails to respond within a preset time to a control output.

K. Restart Program:

1. At least every 5 minutes, save on disk, CPU memory resident data needed to completely characterize current status of CS hardware and software.
2. When system restart is required, use saved data to initialize CPU memory resident data. Use battery operated clock to set time and date. Execute “housekeeping” required to restore system to normal operation.

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L. Man-Machine Interface-General Functions:

1. Operator CRTs: Primary method of operator interface with the CS real-time PMCS.
   a. Configure new CS process variables and report variables.
   b. Configure, view, and change CS process database parameters. Refer to paragraph Process Database.
   c. View and change **[A: DCS] [B: PLC] [C: RTU]** database items such as setpoints, alarm limits, tuning constants, pacing constants, timer/counter preset values, loop status, and sequence START/STOP.
   d. Acknowledge alarms.
   e. Activate Data Retrieval System to get information from Data Collection files for reporting, trending, or listing.
   f. Use log-on, help, legend, index, alarm summary, trend, diagnostic, and configuration.
   g. Configure process graphic displays, tabular displays, and reports.
2. Full access for each operator CRT to all CRT displays.
3. Display Hard Copy:
   a. Initiated by single keystroke on operator CRTs.
   b. Cause full graphic representation current display to be printed on associated display hard copy device.
   c. Works for all CRT displays.
4. Log Changes: For database parameter changes made through an operator CRT log a “change” message on associated alarm/status printer. Include CRT ID or user ID in message.
5. Alarm Window: Dedicated area of CRT screen reserved for display of most recent alarm.
6. Password Protection:
   a. Four-level password protection scheme to prevent unauthorized users from making changes from an operator CRT.
   b. Security Levels:
      1) Engineer’s or Supervisor’s: Access to all database parameters.
      2) Supervisor’s: Access to alarm limits, alarm inhibit status, scan inhibit status, and all operator level functions.
      3) Operator Level: Setpoints, control commands (AUTO/MANUAL, ON/OFF, START/STOP, OPEN/CLOSE), timers, counters.
      4) Display Only: No changes allowed.
   c. Entry from operator CRT of a predefined password places that CRT at assigned access level. Operator CRT remains at this level until a different access level is logged or until user logs off. Log-on operation logs messages naming logged-on user. Passwords entered in nondisplay mode.

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d. Supervisor level display to allow assignment of passwords to at least 40 individual users.

7. Keyboard Entries and Targets: Designed to use a minimum number of keystrokes by making use of targets, function keys, and brief mnemonic codes. Codes that will be entered by operator appear on CRT display being used by operator to make entry.
   a. Targets: Parameter values, status indicators, graphic symbols, or off-page connectors that appear on a CRT display and provide:
      1) Access to modify parameter value or status indicator.
      2) Access to additional information on target.
      3) Access to other related displays.
      4) Execute functions or programs.
      5) Target Selection: Primary methods. Track ball positions screen cursor to target.
      6) Entering through keyboard a one- or two-character code that is displayed adjacent to desired target.
      7) Mouse positions screen cursor to target.
      8) Light pen selects desired target.
      9) Touch screen to select target.
      10) Other Method: Cursor keys position cursor to target.
8. Display Organization: Tree structure with major and minor menu displays that identify access to subsequent displays. Menu displays have targets to displays listed.
9. Display Access:
   a. Indirect access by paging down through menu tree for desired display.
   b. Direct, one step access from display to another desired display by entering identification code of desired display.

M. Graphic Display Generator:

1. Online, interactive, object oriented graphic editor for creating and editing text and graphic displays.
2. Allows user to see static part of display as user is editing it.
3. Object Editing and Linking: Allows object selection, placement, line drawing, and linking display fields to process database and other graphic displays.
   a. Objects: Lines, rectangles, polygons, arcs, circles, text, value fields, and graphic symbols.
   b. Operations: Move, cut, copy, paste, rotate, fill, line weight, font changes, and change color.
4. Graphic Symbol Library:
   a. Includes set of predefined process graphic symbols conforming to ISA 5.5.

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b. Allows addition of user defined symbols and editing of all symbols.

5. Display Formats for Analog Points:
   a. Numbers: Selectable number of digits and decimal places.
   b. Bar Charts: Selectable orientation (horizontal or vertical), height, width, and color.
6. Analog and Discrete Data Point Status: Selectable display of a data quality, out-of-service, and control inhibit status. Status information able to be placed near point value or symbol.
7. Real-Time Displays: Convert static displays created with display editor into dynamic displays that link to process database to and provide real-time updating of dynamic display data.

N. Types of Displays:

1. Help Displays: Assist user in learning to use operator CRT.
   a. Context Sensitive: Display additional information about using operator CRT functions for current display.
   b. Function key actuated.
   c. Include user interface for adding, deleting, and editing Help displays.
2. Alarm Summary Display: Shows all existing alarms and unacknowledged alarms. Refer to paragraph Alarm Handling.
   a. Display format similar to messages logged on alarm/status printer.
   b. Include time of day at which alarm was detected.
   c. Lists alarms in reverse chronological order.
   d. Unacknowledged alarm messages blink.
   e. Single-key acknowledgement of all alarms shown on a currently displayed page of alarm summary display.
3. Disabled Alarm Summary Display: Shows all disabled alarms including time and date at which each was disabled.
4. Process Graphic Displays:
   a. Example Displays: Typical displays are shown on process graphic displays on Drawings. These examples further define level of detail required for process schematic type displays.
   b. Display Objects:
      1) Process Flowstreams: Labeled and color coded.
      2) Process Structures: e.g., Basins, tanks, wet wells, and channels.
      3) Major equipment items, e.g., pumps, blowers, drives, and compressors.
      4) Major control devices, e.g., gates and valves.
      5) Instruments.

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6) Targets to allow quick access associated process graphic displays.
7) Targets to allow quick access to database point parameters.

5. Tabular Process Displays:
   a. Implemented through Graphics Display Generator.
   b. Data values shown in alarm/status colors.
   c. Diagnostic Displays: CS Diagnostic Displays: CS block diagram graphic showing color coded operational status (online, offline, and failed) for each CS device.
   d. TS Diagnostic Displays:
      1) Graphic and tabular displays showing operational status of TS, communication channels, communication lines, and RTUs connected to CS.
      2) Information Displayed: CS scan rates, channel scan rates, RTU scan rates, communication statistics for each RTU (e.g., number of hard and soft errors with point of origin), and communications system configuration.
      3) Menu driven displays for changing scan attributes, channel attributes, RTUs assignment, RTU attributes, RTU card and point assignment, and communications error tolerances.
   e. PLCS Diagnostic Display: Graphic display showing operational status of PCS including data highway, data highway interface, and PLCs.
   f. DCS Diagnostic Display: Graphic display showing operational status of the DCS including data highway, operator CRT, and the DCUs.

O. Alarm/Status Log History:

1. Disk File: Circular file of alarm/status messages logged by alarm/status printer.
2. Tape File: Transfer messages from disk to tape on operator command. Log warning message if less than 25 percent of messages on disk have been saved to tape.
3. Retrieval from Disk or Tape: Based on operator commands to control.
   a. Format for Retrieved Data:
      1) Tabular CRT display.
      2) Report printed on report printer.
   b. Data Screening Criteria:
      1) Time Period: Start and end times/date.
      2) Type of Message: All, Alarm, Change, Status.
      3) Points Covered: All, all for a given facility, all for a given field interface device or a tag number.

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P. Historical Data Collection Files: Periodically save designated variables for trending, report generation, and historical records. Allow all process variable to be selected for saving in data collection files.

1. Data Quality Propagation:
    a. Along with each data value saved in historical files, include its data quality code.
    b. For such computed values as minimums, maximums, and averages, set data quality to indicate:
        1) OK: If $P \leq Qlim$
        2) Questionable: If $Qlim < P \leq Blim$
        3) Bad Data: If $Blim < P$
        4) Where "P" is percent of time that independent variable had bad or missing data or bad data quality. "Qlim" and "Blim" are adjustable limits.
    c. Bad data values are not used in calculation.
2. Data Entry for Manual Inputs:
    a. Direct entry into historical files of data values for manual input variables.
    b. Data entered through menus based on configurable groups of related manual inputs. Each group menu includes tag numbers and descriptions for 1 to 20, minimum, manual inputs. Data entry sequence:
        1) Operator selects a manual input data group.
        2) Operator enters date for data.
        3) CS displays current values (if any) for variables on menu.
        4) Operator enters values for variables.
        5) CS saves values in designated historical file.
3. Corrections: Provide for correcting through an operator CRT of data values in historical files. Set data quality to indicate "inserted" value.
4. Disk Files:
    a. High Resolution Data:
        1) Sample Interval: Adjustable from 1 to 15 minutes.
        2) Period Covered: Multiple day, adjustable.
        3) Content: Time of day, date, tag numbers, and values of designated process variable. Value saved shall be either instantaneous value or average over sample interval.
    b. Hourly Data:
        1) Sample Interval: 1 hour.
        2) Period Covered: Multiple day, adjustable.
        3) Content: Time of day, date, tag numbers, and average hourly values of designated process variables.
    c. Daily Data:
        1) Sample Interval: 1 day.
        2) Period Covered: Multiple day, adjustable

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3) Content:
a) For Designated Process Variables:
(1) Daily minimum and maximum values.
(2) Time occurrence of daily minimum and maximum values.
(3) Average daily value.
(4) Daily total for flow and other rate type variables.
(5) Tag numbers.
b) End of day values for designated run time counters, cycle counters, and their tag numbers.
c) Daily values for designated report variables, manual inputs, and their tag numbers.
4) In case CS is down at midnight, allow manual initiation of this file update at a later time.

5. Historical Tape File: Maintains permanent record of data saved in Daily Data Disk file.
a. On command, copy 1 month of data from Daily Data Disk File to Historical tape file. Copy operation does not alter disk files. Disk data continues to be available for data retrieval functions.
b. Before transferring data, verify that data to be transferred is in sequence with that already on tape.
c. To allow for correction of data on tape, allow last month data on tape to be replaced by revised version of data for same month.
d. Log status message on transfer completion.
e. Log warning message if CS is within 10 days of losing data due to lack of data transfers.

Q. Data Retrieval:

1. Retrieve data from Historical Data Collection files (disk and tape) for listing, trending, and input to user written programs.
2. Retrieval Parameters Selectable by User:
a. Variable: Process variables, report variable, manual input for, or discrete input which data are desired.
b. Data Types:
1) Actual value of variable at end of sample interval.
2) Minimum value of variable during sample interval.
3) Maximum value of variable during sample interval.
4) Total value of variable during sample interval.
5) Average value of variable during sample interval.
6) Run time hours over sample interval (discrete inputs only).
7) Cycles over sample interval (discrete inputs only).

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c. Retrieval Period:
    1) Time period covered by retrieval request:
        a) Starting time/date and length of retrieval period, or
        b) Ending time/date and length of retrieval period.
    2) Within limits of data in files, complete flexibility for selecting retrieval period. For example:
        a) Starting 12:45/10-15-94 for 15 minutes.
        b) Starting 14:30/10-16-94 for 4 hours.
        c) Ending 8:00/9-30-94 for 5 days.
        d) Ending 0:00/11-28-95 for 30 days.
        e) Starting 0:00/12-01-94 for 6 months.
d. Sample Interval: Time interval between data points to be output. Within limits of data files, complete flexibility for selection of sample interval. For example: 1 to 60 minutes, 1 to 24 hours, 1 to 31 days, 1 to 12 months.
e. Type of Output: Listing, ASCII data file, or trend plot.
f. Output Device: Hardware device to which data are to be output:
    1) Operator CRT: List or trend plot.
    2) Printer: List.
    3) Disk File: List.
g. Scaling for Trend Plots: See paragraph Trending.

3. Automatic selection of specific Historical files to access for requested data. Data retrieval from multiple historical tapes if time period to be covered spans more than a single tape.
4. Retrieval requests made from programmer CRT, operator CRT, and user written FORTRAN (or PASCAL) program.

R. Trending:

1. General Features: Simultaneous trending of different sets of variables on different trend output devices.
    a. CRT Trend Resolution: Pixel level.
    b. Variables Per Trend: User selectable, 1 to 4 minimum, all displayed in same trend window.
2. Trend Types:
    a. Real-Time: Continuous plotting of variables as a function of time.
        1) Plotable Variables: Process variables, report variables, discrete variables, and manual inputs.
        2) Minimum Plot Sample Interval: Same as scan rate.
    b. Historical: Plotting variables from Historical Data Collection files as a function of time. Historical trending is a special case of previously specified Data Retrieval function.
3. Retrieval Parameters: Specific variables, data types, retrieval period, sample interval, process variable scales, and output device. Refer to paragraph Data Retrieval.

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4. Process Variable Scales:
    a. Independent selection for each variable of low scale and high scale values in engineering units of process variable axis. For example, if A and B are two variables to be trended on the same graph, and if low scale and high scales for variables A and B are 0.00 to 1.00 and 100 to 200 respectively, and if A equals 0.50 and B equals 150, both A and B would plot at exactly the same point (the mid-point of process variable axis).
    b. Display individual, engineering units scales for each variable being trended.
    c. Readout Cursor: Adjustable by user over range of time scale. Values are displayed in engineering units of each trended variable intersected by readout cursor.
    d. Point Descriptions: Tag number and description are shown for each trended variable.
5. Trend Groups: Aid requesting of frequently used trends.
    a. Each trend group contains all data retrieval parameters needed to specify trend display for up to four variables. Refer to Article Supplement, Example Trend Groups.
    b. Each Trend Group is identified by a 6-character minimum group name and a 20-character minimum group description.
    c. Trend group menu allows selection of any individual Trend groups.

S. Report Generator:

1. Table Driven Report Generator: Used to configure and print reports.
    a. Configuration Process:
        1) Online function using operator CRT without need for programming.
        2) Use of Graphics Display Generator permitted provided that full page size (132 columns by 66 lines) is accessible.
    b. Report Configuration Tables: Used to define:
        1) Page layout.
        2) Specific headings and subheadings.
        3) Variables to be printed.
        4) Calculations required prior to printing.
        5) Nonprinting free form “comments” for documentation purposes.
2. Report Types:
    a. Single day.
    b. Multiple Day: List daily values from 2 to 31 days.
    c. Multiple Month: List monthly values from 1 to 12 months.

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3. Requesting and Printing Report:
   a. Reports requested from operator CRT and printed on report printer.
   b. Operator specifies name of report, type of report (single day, multiple day, or multiple month), start date, end date, number of copies to be printed.
   c. Report variables recompute each time report defining those variables is run. If an independent variable used for a calculation has “bad data” or “missing data” codes, calculation of dependent variable is bypassed and its data quality code set to “unable to calculate due to missing data”.
   d. Multiple reruns of reports are allowed to permit correction of faulty data or entry of previously missing data.
   e. Report Headings for Each Page of Report: Report title, time period covered, time and date at which report was printed, and page number.

Examples of Valid Requests for Reports

Report Type	Start Date	End Date	Period Covered
Single day	13-May-92	13-May-92	Daily report
Multiple day	31-May-92	4-Jun-92	5-Day report
Multiple day	27-Dec-92	2-Jan-93	Weekly report
Multiple day	1-Dec-92	31-Dec-92	Monthly report
Multiple month	Jan-93	Mar-93	Quarterly report
Multiple month	Oct-92	Mar-93	6-Month report
Multiple month	Jan-88	Dec-88	Annual report

2.04 APPLICATIONS SOFTWARE

A. CS Standard Functions: Functional requirements that apply to database variable or of a given type. For example, logging alarm messages is a standard function since it applies to all alarm points.

B. Process Database Spare Capacity: **[A: 50] [B: 100]** percent for base tables and disk files.

C. **[A: CS/PLC] [B: CS/DCS]** Communications:

1. Periodically read all analog and discrete inputs and outputs for each **[C: PLC.] [D: DCS.]**
2. Read or load **[E: internal PLC registers] [F: DCS database value]** including individual timers, counters, timer/counter preset values, control loop setpoints, high/low limits, computed variables, control loop

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tuning constants, status indicators, and sequence START/STOP commands.

3. Read and load these values as required to support man-machine interface and data collection functions.

D. CS/TS Communications:

1. Polling Rate: RTUs polled per unit time. See Section 40 95 60, Telemetry System, Paragraph CS/TS Communications Timing, for requirements.
2. Number of Retries on Communication Failure: Three.
3. Exception Report Dead Band: Plus or minus 1 percent.
4. Polling Interval for Full Report: 15 minutes.

E. Calculated Analog Points (CA):

1. Provide CAs explicitly defined or implicitly required.
2. Examples of Typical CAs: Tank volumes based on level; total flows for areas, zones, subsystems, and systems; and tank levels in feet of elevation.
3. Partial listing of calculated CAs is given in Article Supplements, Calculated Analog Point Summary. This listing is not intended to be all-inclusive. Provide CAs required to provide completely operational system.
4. Fields in Calculated Analog Point Summary:
    a. Field Interface Unit Number.
    b. Variable Name: Process variable name or identifier.
    c. Description.
    d. Nominal Range: Approximate minimum and maximum values expected.
    e. Units: Engineering units.
    f. Alarm Limits.
5. Configure same functions for CAs as for real analog inputs. For example, provide alarm logging, CRT displays, flow integrations, data collection, data retrieval, and trending functions for CAs.

F. Input Processing: Scan all process inputs at frequencies specified under sections defining **[A: RTUs.] [B: PLCs.] [C: DCUs.]**

1. Analog Inputs:
    a. Digital Filter Constant: **[D: Zero.] [E: 10 seconds for pressures and 30 seconds for other analog inputs.]**
    b. Scale Range and Engineering Units: Refer to **[F: Loop Specifications.] [G: Instrument List.] [H: I/O Summary.]**
    c. HIGH/LOW Alarm Limits: Refer to I/O Summary. Disable checking if no limits are shown.

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d. Instrument Failure Detection. Log alarm message when detected. If detection is not handled by field interface units, then set High-High/Low-Low limits to high scale range plus 2 percent and low scale range minus 2 percent, respectively.
e. Alarm Dead Band: 2 percent of instrument range.
f. Rate of change alarm limit set for no alarm.
g. Totalize all flow, power, and other rate type variables.

2. Discrete Inputs:
   a. Alarms: If "type" on I/O summary is ALARM, log alarm message when input changes to high state.
   b. Status Change Logging:
      1) Deactivated for each point.
      2) Normally used only for troubleshooting and activated on fewer that 5 percent of points.
   c. Elapsed Run Time Monitoring: For equipment units with ON/OFF status.
   d. Cycle Counters: **[I: Refer to I/O Summary.] [J: For all Pumps.] [K: For all drives over 25 horsepower.] [L: .]**

G. Control:

1. CS Special Functions: Configure all controls defined under Section 40 90 00, Instrumentation and Control for Process Systems, paragraphs CS Special Functions.
2. CS Standard Functions:
   a. No Response Checking: If a control device fails to respond within a preset time to a control output from CS or a field interface device, log an alarm message that identifies nonresponsive device and requested control output.
      1) Timer Range: 0 to 60 seconds, adjustable in seconds.
      2) Initial Timer Setting: 10 seconds.
   b. Disagree Alarm: Each time a field device is polled, check status of all associated control devices that are currently under CS control. If a status change has occurred that was not the result of a control output, log a "DISAGREE" message.

H. Associated Alarm/Status Printers and Hard Copy Devices:

Operator CRT Location	Associated Alarm/Status Printer	Associated Hard Copy Device
Liquids Control Room	Liquids Control Room	Liquids Control Room
Solids Control Room	Solids Control Room	Central Control Room
Central Control Room	Central Control Room	Central Control Room

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I. Process Graphic Displays:

1. Display Coordination Meeting:
   a. Held prior to entering of process graphic displays.
   b. Purpose is to establish:
      1) Graphic symbols to be used on displays.
      2) Color usage conventions.
      3) Conventions for showing alarm conditions, device status, and process variable values.
      4) Conventions for naming and identifying devices.
      5) Breakdown of process into individual displays.
      6) Preliminary layout for overview displays and for **[A: each process graphic display.] [B: typical process graphic display, up to 10 percent of total required.]**
2. Preliminary Displays by Engineer: After Presoftware Development Submittal has been successfully completed, Engineer will give Contractor set of preliminary process graphic displays. This set will contain no more than **[C: (state number)]** displays.
3. Required Process Graphic Displays: Provide complete set of process graphic displays. An example of at least one of each type of process graphic display is shown on Drawings. These examples include:
   a. Process Overview Graphic for In-plant Processes:
      1) Based on Process Interface Drawing.
      2) Unit process symbols on overview are targets to associated Unit Process Graphic Displays.
   b. Unit Process Graphics:
      1) Detailed displays showing status of all equipment connected to, and all control provided by, **[D: CS.] [E: PLCS.] [F: DCS.]**
      2) Show in P&ID format all monitor and control related data including: equipment status, process variable values, alarm conditions, setpoints, control status, counters, and timers.
      3) Operator's normal access to control functions. For example, while viewing these displays operator can change status, i.e., open or close a valve, change a setpoint, initiate a sequence, etc.
   c. System Map for Remote Facilities:
      1) Map type overview of remote facilities monitored by CS.
      2) Facility symbols on overview display are targets to associated facility graphic displays.
      3) Facility Symbol Colors: Separate colors used to distinguish communication failure, power failure, and process alarm.
   d. Controls Strategy Graphics:
      1) Show overview of control strategies that involve multiple facilities.

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2) Facility symbols are targets to individual Facility Graphics.

e. Facility Graphics:

1) Detailed display for each facility showing current status of that facility.

2) Show in P&ID format all monitor and control related data including: equipment status, process variable values, alarm conditions, setpoints, control status, counters, and timers.

3) Operator's normal access to control functions. For example, while viewing these displays operator can change status, i.e., open or close a valve, change a setpoint, and initiate a sequence.

4. Labels: Label all parameters and show all values in engineering units.

5. Device Status Colors for Graphic Symbols: Flashing red for alarm, steady red for acknowledged alarm, yellow energized, and green for normal or not energized.

6. Access to Point Parameters:

a. Each process graphic display provides access for display and modification of database parameters for process I/O point and calculated point shown on the process graphic display. This is operators normal method of checking and changing database parameters including, process variable range/zero, digital filter time constants, alarm limits, time/counter settings, pacing constants, tuning constants, scan status, alarm inhibited status, setpoints, and loop ON/OFF control status.

b. Parameters are accessed through use of targets and function keys.

7. Spare Capacity for Implementing Process Graphic Displays: **[G: 100] [H: 150] [I: 200]** percent.

J. Other Required Graphic Displays:

1. Legend for Process Graphic Displays: Defines colors and symbols used on process graphic displays.

2. **[A: .]**

K. Required Tabular Process Displays: **[A: .]**

L. Alarm/Status Log History Circular File Size: 4,000 messages minimum.

M. Historical Data Collection Files:

1. High Resolution Data:

a. Sample Interval: 5 minutes maximum.

b. Period Covered: 48 hours minimum.

c. Points Saved: All process variables.

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2. Hourly Data:
    a. Sample Interval: 1 hour.
    b. Period Covered: 62 days.
    c. Points Saved: All process variables.
3. Daily Data:
    a. Sample Interval: 24 hours.
    b. Period Covered: 62 days.
    c. Points Saved: All process variables, manual inputs, run time counters, cycle counters, and report variables.
    d. Manual Inputs: 200, one value per day.
4. Spare Capacity: Same as specified under Paragraph, Process Database.
5. Data Quality Propagation Limits:
    a. Questionable Data Limit: Qlim equals 10 percent.
    b. Bad Data Limit: Blim equals 50 percent.

N. Trend Group Capacity: **[A: 50] [B: 100]** trend groups, minimum.

O. Reports:

1. Required Reports: Provide the following reports:
2. Spare Capacity for Reports: **[A: 100] [B: 50]** percent.

2.05 HARDWARE

A. CS Block Diagram: Refer to figure CS Block Diagram on Drawings. Interconnecting lines shown on block diagram imply information flow and not necessarily wiring.

B. Control Room Layout: Refer to Drawings.

C. Equipment Mounting: Unless otherwise noted, mount all CS components in freestanding metal cabinets or provide with suitable metal stands to bring them to normal operating levels.

D. Color: Color-coordinate CS components to produce an attractive installation.

E. Cables Required:

1. For interconnection between all CS components, except where leased telephone lines are shown.
2. Cables Under 50 Feet Long: Prefabricated with connectors and factory tested with CS.
3. Special signal conditioning/repeating equipment as required for proper operation of CS.

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4. Surge Arrestors: For Connections to CS from equipment outside Central Control Room. To protect CS from damage by electrical transients induced in cables by lighting discharges or electrical equipment.

F. Power to CS Equipment:

1. Central Control Room: Uninterruptible power supply system.
2. Other Locations: 120-volt ac, single-phase, three-wire, 60-Hz.

G. Power Failure Detection and AUTO Restart:

1. Prevents errors due to power failure or short-term power fluctuations that occur when UPS is not operating.
2. Power Failure: Voltage variations in excess of plus or minus 10 percent of normal for a duration of 0.5 second or longer. Causes CS equipment to automatically shut down as required to prevent introducing errors on disk.
3. Short-term Power Fluctuations: Voltage variations in excess of plus or minus 10 percent of normal for durations of 0.5 second to 1 millisecond). CS shuts down as above or is buffered to prevent fluctuations from causing errors.
4. CS executes Restart program and return to normal operation when power is restored. Battery backed-up real-time clock used by CS during automatic restart to set time and date.

2.06 EQUIPMENT

A. CS Component List Format:

1. Quantity: Capacities and quantities shown are minimum. Provide additional capacity or units as necessary to meet the functional requirements. Refer to Drawings where no quantity is listed here.
2. Component Identification Code: Refer to Article Supplements, Component Specifications.

B. CS Component List:

C. Communications Control and Switching: Dual redundant communications control equipment for connection to peripheral devices, and field interface units.

1. Communications Processors:
   a. Function: Handle all communication with devices that are dedicated to an individual CPUs.
   b. Options: On Drawings communications processors are shown as external to the CPUs. Provided that CPUs have sufficient

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processing power, functions of communications processors may be integral to CPUs.

c. Channels: As required to support all supplied peripheral and communications interfaces.

d. Spare Capacity: 20 percent, minimum.

2. Communications Switching Unit:

a. Provide for switching of devices between CPUs.

b. Three-position (A, B, ONLINE), manually operated switch for each connected device. In “A” and “B” positions, associated device is connected to CPU “A” or “B”, respectively. In “ONLINE” position, device is automatically connected to the “ONLINE” CPU.

c. Channels: As required to handle all channels provided with communications processor.

d. Spare Capacity: 20 percent, minimum.

2.07 EQUIPMENT GROUPS

A. CS Equipment Group 1 (Initial Programming Equipment):

B. CS Equipment Group 2 (Test System):

2.08 TEST EQUIPMENT AND TOOLS

A. **[A: .]**

2.09 SOURCE QUALITY CONTROL

A. Factory Demonstration Test: Test all nonloop-specific functions including, but not limited to:

1. Failure mode and backup procedures including power failure, AUTO restart, and disk backup and reload.
2. Dual Computer Operation: Processor transfer modes, peripheral switching, and communications switching.
3. Message logging and alarm handling.
4. Communication with field interface units.
5. Data acquisition.
6. Man-Machine Interface: Database and display configuration and use of all types of displays.
7. Data collection and data retrieval.
8. Report Generation: Creation of a typical report and production of specified reports.
9. Control configuration processor.
10. System Software: Operating system, programming languages, and utility functions.

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PART 3 EXECUTION

3.01 FIELD QUALITY CONTROL

A. Operational Readiness Test.

B. Performance Acceptance Test: Include the same types of testing that are specified for Factory Demonstration Test.

C. Reliability Acceptance Test.

3.02 MANUFACTURER'S SERVICES

A. **[A: .]**

3.03 TRAINING

A. Operations:

1. Training Session Duration: **[A: 10] [B:]** instructor days.
2. Number of Training Sessions: **[C: Three.] [D: .]**
3. Break training sessions into **[E: three] [F:]** parts with at least 4 weeks between parts.
4. Location: Project Site.
5. Content: Using man-machine interface functions from process operator's standpoint.

B. Hardware Maintenance Factory Training:

1. Training Session Duration: **[A: 10] [B:]** instructor days.
2. Number of Training Sessions: **[C: One.] [D: .]**
3. Location: Factory or training center.
4. When: Before Factory Demonstration Test.
5. Number of Students: **[E: Three] [F:]** persons.
6. Content:
    a. Standard hardware maintenance for CS equipment.
    b. How equipment and components are connected and set up for Project.
    c. Test, adjustment, and calibration procedures.
    d. Troubleshooting and diagnosis.
    e. Component removal and replacement.
    f. Periodic maintenance.

C. Hardware Maintenance Onsite Training:

1. Training Session Duration: **[A: 6] [B:]** instructor days.
2. Number of Training Sessions: **[C: One.] [D: .]**

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3. Break training sessions into **[E: two] [F:]** parts with at least 4 weeks between parts.
4. Location: Project Site.
5. Content: Similar to factory training but uses installed hardware.

D. Software Maintenance Factory Training:

1. Training Session Duration: **[A: 8] [B:]** instructor weeks.
2. Number of Training Sessions: **[C: One.] [D: .]**
3. Location: Factory or training center.
4. Break training sessions into **[E: two] [F:]** parts with at least 4 weeks between parts.
5. When: Before Factory Demonstration Test.
6. Number of Students: **[G: Two] [H:]** persons.
7. Design training for students having had **[I: a one-semester class in FORTRAN, BASIC, or PASCAL, but no professional programming experience.] [J: 1 year of experience in using personal computers, but no experience with mini computers.]**
8. Purpose: To provide Owner staff with sufficient training so that they can maintain CS software on a day to day basis.
9. Content:
    a. System Overview: Basic system design, configuration, functions, maintenance, and operation.
    b. System Hardware: Specific hardware provided.
    c. System Software:
        1) Operating system, assembler, and compiler details.
        2) Backup, reload, restart, and failover procedures.
        3) Utilities, compilers, debugging aids, file management, and system generation.
        4) Diagnostic Software: Capabilities, usage, and interpretation of results.
    d. PMCS:
        1) Process database.
        2) Communication with field devices.
        3) Calculated analog and discrete points.
        4) Input processing.
        5) Message logging.
        6) CS Diagnostic Alarms.
        7) Alarm Handling.
        8) Control Processor.
        9) Restart Program.
        10) Man-Machine Interface-General Functions.
        11) Graphics Display Generator.
        12) Types of Displays.
        13) Alarm/Status Log History.

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14) Historical Data Collection, Data Retrieval and Trending.
15) Report Generator.

e. Applications Software: Detailed training on database, file, display, report, and control configuring provided.

E. Software Maintenance Onsite Training:

1. Training Session Duration: **[A: 3] [B:]** instructor weeks.
2. Number of Training Sessions: **[C: One] [D: .]**
3. Location: Project Site.
4. Break training sessions into **[E: two] [F:]** parts with at least 4 weeks between parts.
5. Purpose: To provide Owner staff with sufficient training so that they can maintain CS software on a day-to-day basis.
6. Content: Similar to factory training except uses installed hardware and software.

3.04 SUPPLEMENTS

A. The supplements listed below, following End of Section, are a part of this Specification.

1. Network Hardware Equipment List.
2. Network Software List.

END OF SECTION

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Type	Description	Manufacturer	Model	P&ID	Tag	QTY	Notes
Virtual Server Host and Storage (SCADA)	Nutanix 1365-G5 Hyperconverged 3 Node Cluster. Acts as shared storage and Virtual Machine Hosts (Includes 3yrs of 24x7 Support)	Nutanix	NX-1365-G5				
Virtual Server Host (DMZ)	Dell PowerEdge R730 Server SKU 210-ACXU plus memory and components	Dell	Dell R730				
Physical Server Security	Dell PowerEdge R730 Server SKU 210-ACXU plus memory and components	Dell					
Thin Clients	Wyse 3030	Wyse	329-BDBF				
Thick Clients	Dell Optiplex XE2 Mini Tower PC	Dell	338-BCIS				
Network Storage for Backup	Synology Rack Station NAS server with Seagate Hard Drives. Storage used as backup repository.		RS815+				
KVM's	Dell Analog 8 Port KVM SKU DAV2108 - 1 each Keyboard, Video, Mouse Controller switch for each server	Dell	DAV2108, FPM185, A7547276, A748911				
Monitors for Thick Clients and Servers	Dell 24 inch 1920 x 1080 LED KMM	Dell					
GPS Time Servers	TimeTools GPS time servers for each plant site. Keeps SCADA System Time Syncronized.						
Network Core Switches (SCADA)	10GB uplinks to accommodate SAN configuration includes all fiber SFP's and redundant power supplies						
Network Switch (SCADA)	Gig Rack Mounted Switch - Used for DMZ Connectivity						
Network Switch (DMZ)	Gig Rack Mounted Switch - Used for DMZ Connectivity						
Network Switch (Internet)	Managed Switch for Internet Connectivity						
Business Switches	For Business and Phone						
Security Switches	For Security						
Firewall	SCADA and Business Firewall						
Microwave Radio	Ceragon 11ghz, 1 at Nageezi, 1 at T2, 1 at T3, 1 at WTP	Ceragon					
Battery/UPS for radios	T2, T3, plant See NTUA e-mail about UPS/Batt preference						
Switch for 11 ghz radios	need part number for Siemens switch at Nageezi						
Battery/UPS for radios	Used at Tank T3, plant See NTUA e-mail about UPS/Batt preference						
Switch for 11 ghz radios	need part number for Siemens switch at Nageezi						
Radio	CER IP-20S 11G,TX High,CH1-6,No MIMO	Ceragon	IP-20S-HP-11-500-1W6-H-E				
Radio	CER IP-20S 11G,TX Low,CH1-6,No MIMO	Ceragon	IP-20S-HP-11-500-1W6-L-E				
	CER SL-0287-0 - Capacity 200M, per carrier	Ceragon	IP-20-SL-CAPACITY-200M				
	CER SL-0284-0 - Capacity 50M, per carrier	Ceragon	IP-20-SL-CAPACITY-50M				
	CER IP-20 SL - ACM, per carrier	Ceragon	IP-20-SL-ACM				
	CER PoE Injector Outd.,Redund.DC,+24VDC	Ceragon	POE_INJ_AO_2DC_24V_48				
	CER CAT5E SFUTP Outdoor 100m Drum	Ceragon	CAT5E_SFUTP_OUTDOOR				
	CER HighSpeed Ground Kit,CAT5e OD Cable	Ceragon	CAT5E_GND_KIT				
	CER IP-20C_Glands_x3_kit	Ceragon	IP-20_3XGLANDS_KIT				
	CER GBE Connector Kit	Ceragon	GBE_CONNECTOR_KIT				
	CER Ground Cable for IDU & ODU	Ceragon	CBL-GND				
	OUTDOOR TIES 50pcs	Ceragon	MISC.CHARGE				
	AC/DC OUTDOOR 150W AC/DC,150W,INPUT 90~29	Ceragon	MISC.CHARGE				
	CER 4' ANT,SP,11G,Crgn&Std UBR100,Andrew	Ceragon	AM-4-11W-A				
	CER 2' Ant,SP 11GHz,CER&Std UBR100 Int.	Ceragon	AM-2-11W-A				

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Description	Quantity	Manufacturer	Model Number	Network	Remarks
System Platform 2014R2, 25K IO/5K History Application Server 25K IO w/ 4 Application Server Platforms, Historian Server 5K Tag Enterprise Edition, 2 Device Integration Servers, Information Server w/ 1 IS Advanced CAL (local only)	1	Wonderware	SP-4375A	SCADA	For Primary and Secondary HMI, Non-Redundant Historian, Galaxy Repository
Development Studio 2014R2 Unlimited, Unlim/60K/500	1	Wonderware	97-1356	SCADA	For Engineering Servers
InTouch for SystemPlatform 2014R2 w/ HistClient	1	Wonderware	01-3429	SCADA	HMI Client for Thick Operator Workstation
InTouch for SystemPlatform 2014R2 w/ HistClient (RDS) Remote Desktop Server(Primary)	1	Wonderware	01-3429T	SCADA	Primary HMI RDS Client License
InTouch for SystemPlatform 2014R2 w/ (RDS) Remote Desktop Server(Session/paper license)	7	Wonderware	01-3429TP	SCADA	Additional HMI RDS Client Licenses
InTouch for SystemPlatform 2014R2 w/ HistClient (RDS) Remote Desktop Server Concurrent (Primary)	1	Wonderware	01-3435T	SCADA	Primary HMI InTouch Access Anywhere License
InTouch for SystemPlatform 2014R2 w/ HistClient (RDS) Remote Desktop Server Concurrent (Session/paper license)	2	Wonderware	01-3435TP	SCADA	Additional HMI InTouch Access Anywhere Licenses
Wonderware Customer FIRST SupportStandard Level-One (2) year from purchase date to include technical support and version upgrades for the above licenses only. Additional licenses registered to site will affect support cost	1	Wonderware	STDS-019N	SCADA	Software Support
Alarm Dialer Software	1	WIN-911 Software	WIN-911/Pro	SCADA	Alarms to be provided by voice, text and/or email.
Windows Server 2012 R2 Standard OS - Business Server VMs	1	Microsoft		Business	VMs: File/print (2VMs per license)
Windows Server 2012 R2 Standard OS - DMZ Server VMs	3	Microsoft		DMZ	VMs: Update, Backup, Email Relay, Wonderware Access Anywhere, read only domain controller (2VMs per license)
Windows Server 2012 R2 Standard OS - SCADA Servers VMs	6	Microsoft		SCADA	VMs: Primary HMI, Secondary HMI, Engineer, Primary DC, Secondary DC, Galaxy Repository, Historian, Remote Desktop Server, Alert Server, Engineering Server, Monitoring Server, Backup, Utility Server (2 VMs per license)
Windows Server 2012 R2 User CALs	15	Microsoft		SCADA	Client Access Licenses
Windows Server 2012 RDS User Licenses	15	Microsoft		SCADA/BUSINESS	Remote Desktop Server User Licenses
Windows 8.1 Pro OS - LIMS Workstations Admininstration Building	1	Microsoft		Business	(1) LIMS Workstation
Windows 8.1 Pro OS - HMI View Node Workstations	1	Microsoft		SCADA	(1) Thick Client
Windows 8.1 Pro OS - Engineering Workstation	1	Microsoft		SCADA	(1) Virtual Engineering Workstation
Windows 8.1 Pro OS - Laptop	1	Microsoft		SCADA	

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Description	Quantity	Manufacturer	Model Number	Network	Remarks
Virtual Machine Software for SCADA Server Hosts	1	VMWare	VS6-ESP-KIT-C	SCADA	For 3 SCADA Virtual Server Hosts - Up to 2 socket per server.
Virtual Machine Software for SCADA Server Hosts - 3Yr Production Support	3	VMWare	VS6-ESP-KIT-P-SSS-C	SCADA	For SCADA Servers Support and Updates
Virtual Machine Software for DMZ Server Host	1	VMWare	VS6-ESSL-KIT-C	SCADA	For DMZ Server
Virtual Machine Software for DMZ Server Host - 3 Yr Subscription	3	VMWare	VS6-ESSL-SUB-C	SCADA	3yr subscription for DMZ Server OS Updates
Virtual Machine Software for Business Server Host	1	VMWare	VS6-ESSL-KIT-C	SCADA	For Business Server
Virtual Machine Software for Business Server Host - 3 Yr Subscription	3	VMWare	VS6-ESSL-SUB-C	SCADA	3yr subscription for Business Server OS Updates
Backup Software for SCADA/DMZ Server Hosts	3	Veeam	P-ESSSTD-VS-P0000-00	SCADA	For 5 physical hosts (3 SCADA hosts 1 socket each, 1 DMZ host 1 sockets, 1 Business host 1 CPU) - For VM and data backups, per socket licensing
Microsoft Office - Virtual Servers	5	Microsoft	Office 2013 Standard	SCADA	(1) at engineering server, (1) at historian server, (3) as needed
Anti-Virus Software for DMZ Servers	5	ESET	File Security for Microsoft Windows Server	DMZ	
Anti-Virus Software for SCADA Network Servers	15	ESET	File Security for Microsoft Windows Server	SCADA	

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SECTION 40 95 80
FIBER OPTIC COMMUNICATION SYSTEM

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards that may be referenced in this section:

1. Electronic Components, Assemblies, and Materials Association (ECA): 310-E, Cabinets, Racks, Panels, and Associated Equipment.
2. Institute of Electrical and Electronic Engineers, Inc. (IEEE): 802.3, Telecommunications and Information Exchange Between Systems—Local and Metropolitan Networks.
3. Insulated Cable Engineers Association (ICEA):
   a. S-83-596, Optical Fiber Premises Distribution Cable.
   b. S-87-640, Optical Fiber Outside Plant Communications Cable.
   c. S-104-696, Indoor-Outdoor Optical Fiber Cable.
4. International Organization for Standardization (ISO): 9001, Quality Management Systems—Requirements.
5. International Telecommunication Union (ITU): T G.652, Characteristics of a Single-mode Optical Fibre and Cable.
6. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
7. QuEST Forum (QF): TL 9000, Quality Management Systems.
8. Rural Development Utilities Programs (RDUP):
   a. 7 CFR 1755.902, Minimum Performance Specification for Fiber Optic Cables.
   b. 7 CFR 1755.903, Fiber Optic Service Entrance Cables.
9. Telecommunications Industry Association (TIA):
   a. 526-7, OFSTP-7 Measurement of Optical Power Loss of Installed Single-Mode Fiber Cable Plant.
   b. 526-14, OFSTP-14 Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant.
   c. 568-C.1, Commercial Building Telecommunications Cabling Standards.
   d. 568-C.3, Optical Fiber Cabling Components Standard.
   e. 598, Optical Fiber Cable Color Coding.
   f. 606, Administration Standard for Commercial Telecommunications Infrastructure.
10. Telecommunications Industry Association/Electronics Industry Association (TIA/EIA):
    a. 455-78, FOTP-78 - IEC 60793-1-40 Optical Fibres Part 1-40: Measurement Methods and Text Procedures – Attenuation.

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b. 455-133, FOTP-133 IEC-60793-1-22 Optical Fibres Part 1-22: Measurement Methods and Test Procedures Length Measurement.
c. 492AAAA, Detail Specification for 62.5-Micrometer Core Diameter/125-Micrometer Cladding Diameter Class Ia Graded-Index Multimode Optical Fibers.
d. 492AAAB, Detail Specification for 50-Micrometer Core Diameter/125-Micrometer Cladding Diameter Class Ia Graded-Index Multimode Optical Fibers.
e. 492AAAC, Detail Specification for 850-nm Laser-Optimized, 50-um Core Diameter/125-um Cladding Diameter Class Ia Graded-Index Multimode Optical Fibers.
f. 492CAAA, Detail Specification for Class IVa Dispersion-Unshifted Single-Mode Optical Fibers.
g. 492CAAB, Detail Specification for Class IVa Dispersion-Unshifted Single-Mode Optical Fibers with Low Water Peak.
h. 604-2, FOCIS-2 Fiber Optic Connector Intermateability Standard, Type ST.
i. 604-3, FOCIS-3 Fiber Optic Connector Intermateability Standard, Type SC and SC-APC.
j. 604-12, FOCIS-12 Fiber Optic Connector Intermateability Standard, Type MT-RJ.
k. 942, Telecommunications Infrastructure Standard for Data Centers.
l. TSB-140, Additional Guidelines for Field-Testing Length, Loss and Polarity of Optical Fiber Cabling Systems-Contains Color.

11. Underwriter Laboratories (UL): 94, Tests for Flammability of Plastic Materials for Parts in Devices and Appliances.

1.02 DEFINITIONS

A. ATM: Asynchronous Transfer Mode.

B. AUI: Attachment Unit Interface.

C. dB: Decibel.

D. DNI: Desktop Network Interface.

E. EMB: Effective Modal Bandwidth.

F. ETL: Electrical Test Laboratories.

G. FDDI: Fiber Distributed Data Interface.

H. FIM: Facilities Information Management.

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I. Flux Budget: Difference between transmitter output power and receiver input power required for signal discrimination when both are expressed in dBm.

J. FOCS: Fiber Optic Communication System.

K. FOIRL: Fiber Optic Inter Repeater Link.

L. Fusion Splice: Connecting ends of two fibers together by aligning fiber ends and applying electric arc to fuse ends together.

M. Hybrid Cable: Cable containing more than one type of fiber.

N. LAN: Local Area Network.

O. LIMS: Laboratory Information Management System.

P. m: Micrometer.

Q. Mbps: Megabits per Second.

R. Mechanical Splice: Connecting ends of two fibers together by means other than fusion.

S. Megahertz (MHz): One million cycles per second.

T. MHz: Megahertz.

U. micro: x 10^{-6}.

V. Micron: Micrometer or one millionth meter.

W. MIS: Management Information System.

X. n, nano: x 10^{-9}.

Y. N: Newton.

Z. nm: Nanometer—unit of measure equal to one billionth meter.

AA. OFL: Over-filled Launch.

BB. OFN: Nonconductive Optical Fiber Cable.

CC. OFNP: Nonconductive Optical Fiber Plenum Cable.

DD. OFNR: Nonconductive Optical Fiber Riser Cable.

EE. OLTS: Optical Loss Test Sets.

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FF. OTDR: Optical Time Domain Reflectometer.

GG. OVD: Outside Vapor Deposit.

HH. PIC: Process Instrumentation and Control.

II. Plenum: Air return path of central air handling system, such as open space above suspended ceiling.

JJ. RLM: Restricted Mode Launch.

KK. ROL: Reverse Oscillation Lay.

LL. SPC: Super Physical Contact.

MM. UPC: Ultra Physical Contact.

NN. UPS: Uninterruptible Power Supply.

OO. V ac: Volts Alternating Current.

PP. WAN: Wide Area Network.

QQ. **[A: .]**

1.03 SYSTEM DESCRIPTION

A. Function of FOCS is to transmit digital data between network nodes. Requirements listed identify minimum acceptable system performance.

B. Provide a FOCS based on referenced standards for use in the following local and wide area networks:

1. In-Plant Ethernet Network.
2. In-Plant and Outside Plant Fiber Installation: Multi-mode fiber.

C. Network(s) will be used by Plant SCADA and Administration to distribute data and coordinate CH2M HILL's operations.

1.04 SUBMITTALS

A. Action Submittals:

1. Site Layout Diagram Showing:
   a. Access holes, with identification.
   b. Abovegrade cable routings, with pole and cable identification.
   c. Belowgrade conduit routings between access holes and buildings, with conduit counts and identification.

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d. Belowgrade innerduct routings through conduits, with innerduct counts and identification.
e. Cable routings through innerducts and to patch panels, fiber centers, or network nodes, with cable and node identification.

2. Cable Schedule Showing:
   a. Cable identification.
   b. Fiber counts for each cable and identification of used fiber pairs.
   c. Cable length and attenuation, with two connector pairs and no planned splice(s), based on TIA 568-C.3, Annex H.
3. Component Data:
   a. Manufacturer and model number.
   b. General data and description.
   c. Engineering specifications and data sheet.
   d. Scaled drawings and mounting arrangements.

B. Informational Submittals:

1. Manufacturer's statement that installer is certified to perform installation Work.
2. Subcontractor Qualifications:
   a. FOCS Subcontractor: Minimum of 5 years' experience providing, integrating, installing, and commissioning of similar systems.
      1) Statement of Experience: List of at least five fiber optic data communications systems comparable to system specified which have been furnished and placed into operation. For each system, provide following information:
         a) CH2M HILL or other Design Build (DB) Engineer name, address, telephone number, and name of current operations supervisor or other contact.
         b) Description of system hardware configuration, including major equipment items, number of nodes, and communication standards implemented.
         c) System block diagram.
         d) Dates when contract was signed, equipment was delivered, and system was accepted by CH2M HILL or other Design Build (DB) Engineer. Also, include originally scheduled completion date and if different from actual date, explain why.
         e) Approximate value of listed FOCS provided in dollars.
         f) Detailed horizontal and riser routing.
         g) Distribution frame arrangements.
         h) Fiber and termination identification, including spares.
   b. FOCS Subcontractor's Site Representative: Minimum of 5 years' experience installing similar systems.

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c. Qualification of Personnel:
    1) Resumes identifying management and technical qualifications of supervisory, local service representative, and key personnel.
    2) Qualification data of firm and persons to demonstrate capabilities and experience in the following areas:
        a) Fiber optic cable handling and placement techniques.
        b) Fiber optic splicing and installation of connections.
        c) Attenuation testing procedures.
d. CH2M HILL acceptance of FOCS Subcontractor does not exempt FOCS Subcontractor or Contractor from meeting Contract Document requirements nor does it give prior acceptance of subsystems, equipment, materials, or services.
e. Sample of Network Test Report, minimum 10 pages, that Contractor generated in a previous project.
f. Testing and acceptance plan, 30 days prior to beginning of testing.
g. Fiber test results. Documentation covering fiber facility testing, not later than 2 days after testing, showing:
    1) Manufacturer's tag of attenuation per fiber as recorded from OTDR reading before shipment.
    2) Attenuation of each fiber upon delivery to Site.
    3) Attenuation of each fiber plus connector after installation as recorded from OTDR with tracing.
    4) Flux Budget calculations with comparison to measured attenuation for each run verifying adequate optical signal strength.
h. For each maintenance organization, identify location of base of service and how required coverage will be achieved.

3. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements
4. Manufacturer's suggested installation practice.
5. Operation and Maintenance Data: As specified in Section 01 78 23, Operation and Maintenance Data.

1.05 ENVIRONMENTAL REQUIREMENTS

A. Optical Fiber Cable and Cable Splice Centers:

1. Outside, Underground/Submerged: Minus 20 degrees C to 40 degrees C.
2. Outside, Overhead: Minus 40 degrees C to 80 degrees C.
3. Outside, Aboveground in Conduit: Minus 40 degrees C to 80 degrees C.
4. Inside: 0 degree C to 40 degrees C.

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B. Equipment:

1. Outside, Aboveground: Minus 40 degrees C to 80 degrees C.
2. Control Rooms, Equipment Rooms, and Telecommunications Closets: 30 percent to 55 percent relative humidity, 18 degrees C to 24 degrees C.
3. Other Interior Areas: 0 percent to 100 percent relative humidity, 5 degrees C to 35 degrees C.

1.06 QUALITY ASSURANCE

A. Manufacturer Qualifications:

1. Cable:
   a. ISO 9001 or QF TL 9000 registered, whichever applies to material.
   b. Minimum of 20 years in manufacturing optical fiber cable in order to demonstrate reliable field performance.
2. Housing: ISO 9001 and QF TL 9000 registered.
3. Connector:
   a. ISO 9001 or QF TL 9000 registered.
   b. Minimum 10-year history of manufacturing and supporting connector technology that does not require epoxy or polishing in field.
4. Jumper Cable: ISO 9001 and QF TL 9000 registered.

B. Installer Qualifications:

1. Individuals with at least 3 years of experience with projects utilizing fiber optic cable in compliance with TIA 568-C.3.
2. Certified by fiber cable manufacturer.

C. Tester Qualifications: Individuals with at least 3 years of experience with projects utilizing fiber optic cable in compliance with TIA 568-C.3.

1. Technician: Successfully attended training program, which includes testing with an OLTS and an OTDR and have obtained a certificate as proof thereof. Certificate may have been issued by the following organizations or an equivalent organization:
   a. Manufacturer of fiber optic cable and fiber optic connectors.
   b. Manufacturer of test equipment used for field certification.
   c. Other independent training organizations acceptable to CH2M HILL.

D. Provide connectors/coupling, splicing enclosures, mounting hardware, and miscellaneous accessories for fibers by same manufacturer.

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PART 2 PRODUCTS

2.01 FIBER OPTIC CABLE

A. 50/125 and 62.5/125-micron, graded-index for use in backbone and horizontal distribution subsystems, meets or exceeds the requirements of TIA 568-C.3, including the following specifications:

1. Maximum Mean Fiber Loss:
   a. 3.5 dB per km at 850 nm.
   b. 1.5 dB per km at 1,300 nm.
2. Minimum OFL Bandwidth:
   a. OM2-500 MHz•km minimum at 850 nm; TIA 492AAAB.
   b. 500 MHz•km minimum at 1,300 nm.
3. Distance Capacity per IEEE 802.3:
   a. 100Mbit Ethernet: OM2 300m at 850 nm and 2000m at 1,310 nm.
   b. 1 Gbit Ethernet:
      1) OM2: 600m at 850 nm and 600 at 1310 nm.
   c. 10 Gbit Ethernet—10km at 850 nm and 40km at 1310 nm:
      1) OM2: 82m at 850 nm and 600 at 300 nm.

B. Type 50/250 OM2 , Backbone for Underground Conduit Installation:

1. Individual Fibers: 50/125/250 microns.
2. Assembly:
   a. Nonmetallic, gel-free, dry water blocked, loose-tube fiber core with dielectric strength member enclosed by nonmetallic cross-ply sheath; requires buffer tubing.
   b. Cable: Comply with ICEA S-87-640.
3. NEC/UL Listing: None; not approved for general use within building except when installed in metallic conduit.
4. Protective Covering: Black, antifungus, UV-resistant, polyethylene jacket with rip-cord.
5. Minimum Short Term Pull Strength: 600 lbf.
6. Manufacturers and Products:
   a. Corning Cabling Systems; ALTOS loose-tube dielectric cable.
   b. Mohawk; Outdoor loose-tube cable.

C. Type **[A: 50/250 [B: OM2] [C: OM3] [D: 62.5/250 OM1]**, Backbone for Underground Conduit and Building Riser Installation:

1. Individual Fibers: 50/125/250 microns.
2. Assembly:
   a. Nonmetallic, gel-free, dry water blocked, loose-tube fiber core with dielectric strength member enclosed by nonmetallic cross-ply sheath; requires buffer tubing.
   b. Cable: Comply with ICEA S-104-696.

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3. NEC/UL Listing: OFNR.
4. Protective Covering: Black, flame and UV-resistant, thermoplastic jacket with rip-cord.
5. Minimum Short Term Pull Strength: 600 lbf.
6. Manufacturers and Products:
    a. Corning Cabling Systems; FREEDM cable.
    b. Mohawk; RiserLite loose-tube cable.

D. Type 50/900 OM2 Indoor/Outdoor Cable:

1. Individual Fibers: 50/125/250/900 microns.
2. Assembly:
    a. Distribution Style with core of individually tight-buffered fibers surrounded by nonmetallic sheath.
    b. Cable: Comply with ICEA S-83-596.
3. Protective Covering: Flame retardant outer jacket with pull string.
4. NEC/UL Listing: OFNR Low Smoke Zero Halogen.
5. Manufacturers and Products:
    a. Corning Cabling Systems; (MIC) cable.
    b. Mohawk; Distribution Riser cable.

2.02 MULTICELL CONDUIT SYSTEM

A. Nonmetallic, designed for fiber optic cabling and telecommunications.

B. Flexible Fiber Innerduct:

1. Function: Installs into conduit system provided by others, to provide smooth, low-friction path through conduit, with only one cable per path to facilitate changing individual cables.
2. Features:
    a. Size and Count
        1) 2-inch two-cell located within 2-inch diameter conduit, unless otherwise noted.
        2) 3-inch three-cell located within 3-inch and greater diameter conduit, unless otherwise noted.
    b. Material: Fiber.
    c. Color Code: Orange as coordinated with CH2M HILL.
    d. Strength: Minimum 2500-pound tensile strength, with no more than 5 percent ovalization at 600-pound tension.
    e. Lubrication: Prelubricated.
    f. Preloaded pull string.
3. Manufacturers:
    a. MaxCell Fabric Innerduct.
    b. CableGuide Fabric Innerduct.

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C. Corrugated Flexible Sleeves:

1. Function: Exposed applications including cable trays, cabinets, and fiber routing between handholes and associated Network Interface Panels to provide smooth, low friction path through conduit, with only one cable per path to facilitate changing individual cables.
2. Features:
   a. Size and Count: Two 1-inch sleeves routed within outer conduits. 1-inch sleeves routed within cable trays to support quantity of fiber-optic cable runs.
   b. Type: Corrugated flexible and fire resistant.
   c. Material: HDPE.
   d. Color Code: Orange, blue, green, brown, white, or grey as coordinated with the Authority.
   e. Strength: Minimum 600-pound tensile strength, with no more than 5 percent ovalization at 600-pound tension.
   f. Lubrication: Prelubricated.
3. Manufacturers:
   a. Carlon Fire-Flex GP Duct.
   b. Carlon Fire-Flex Riser Duct.
   c. Future Path.

2.03 ETHERNET FIBER TO COPPER TRANSCEIVERS

A. Function: Convert half/full-duplex fiber optic Ethernet signal to copper Ethernet signal and vice versa.

B. Speed: Auto-negotiating 10/100/1000.

C. Features:

1. Support fiber optic type specified.
2. Fiber Optic Connectors: LC connectors preferred unless otherwise required for SC and ST ancillary devices.
3. Copper Connector: RJ45 unshielded.
4. Power:
   a. Powered by signal.
   b. 120V ac or 24V dc power source.
5. Mounting: Suitable for permanent mounting.
6. Fiber Signal Distance: 100 feet minimum.

D. Manufacturers:

1. Moxa; IMC Series Media Converters.
2. Black Box; LIC/LGC Series Industrial Media Converters.
3. OmniTron; Flexpoint Series Media Converters.
4. N-Tron; MC Series Industrial Media Converters.

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2.04 FIBER DISTRIBUTION FRAME

A. Function: Provides industry-standard rack mounting system for interface between fiber optic backbone and equipment cables.

B. Features:

1. Used in either cross-connect or interconnect configuration.
2. 23-inch (584-mm) rack for mounting 19-inch (483-mm) rack mount units.
   a. Accommodates up to 576 fiber terminations per frame.
   b. Accepts connector module housing and splice housing within same rack.
3. Fiber Optic Connectors: **L**C connectors preferred unless otherwise required for SC and ST ancillary devices.

4. Fiber/Wire Management System:
   a. Vertical: 75-mm by 100-mm supports on 200-mm centers vertically on four sides (front LHS, back LHS, front RHS, back RHS).
   b. Horizontal: Supports on 100-mm centers horizontally above and below each termination frame front and back. Support may serve frames immediately above and below.
5. Mounting Hardware: Accepts standard 19-inch (483-mm) rack for integrated fiber optic system (for example, hubs, routers, patch panels).
6. Splice Trays with Coil Former: Former to wind slack cable around, provides controlled long radius bends.
   a. Doors: Pivot down lockable.
   b. Foot and End Caps: Included in final, assembled unit.
   c. Ancillaries: Jumper troughs and covers, cable tie brackets.

C. Manufacturers:

1. Ortronics.
2. Siecor.

2.05 FIBER CENTERS

A. Function: Provides secure place to terminate fiber optic cables.

B. Features:

1. Compartments: Two; one for fiber optic cable, one for jumpers to individual equipment.
2. Coil Former: Former to wind slack cable around, provides controlled long radius bends.

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3. Connectors: Minimum 24 **LC** connectors for entry and exit unless otherwise required for SC and STA ancillary devices.
4. Size: Maximum 450 mm by 300 mm by 100 mm.
5. Construction: 1.5-mm steel with corrosion proof finish.
6. Mountings: Suitable for permanent attachment as shown, or provide separate mountings that do not obscure covers and doors.
7. Doors: Separate doors for cable and jumper terminations.

C. Manufacturers:

1. Ortronics.
2. AT&T.
3. Siecor.

2.06 HOUSINGS

A. Termination Housing:

1. Rack mountable connector housing.
2. Mountable in ECA 310-E compatible 465-mm or 592-mm rack.
3. Available in several sizes, including 1U, 2U, 3U, and 4U.
   a. One ECA rack space or panel height (denoted as U) is defined as being 44.45 mm in height.
4. In accordance with design requirements of TIA 568-C.3 and polymer compounds flammability requirements of UL 94.
5. Manufactured using 16-gauge aluminum or equivalent for structural integrity.
6. Finished with wrinkled black powder coat for durability.
7. Provide black installation fasteners.
8. Available sizes with their corresponding fiber capacities are noted below:

Termination Housing Sizes and Fiber Capacities

Unit Size	Panel Capacity	Fiber Capacity with 6f Panels	Fiber Capacity with 12f Panels	Fiber Capacity with 24f Panels
1U	2	12	24	48
2U	4	24	48	96
3U	6	36	72	144
4U	12	72	144	288

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2.07 PANELS

A. Closet Connector Housing Panel:

1. Manufactured from 16-gauge cold rolled steel or injection-molded polycarbonate for structural integrity.
2. Designed to accommodate applications requiring specified labeling.
3. Offered in 6-fiber, 8-fiber, 12-fiber, 16-fiber, and 24-fiber versions.
    a. 8-fiber and 12-fiber versions shall include LC Compatible Connector preferred for otherwise required for SC and STA ancillary devices.
    b. For high-density applications, MT-RJ and LC duplex panels shall be available in 16-fiber and 24-fiber versions.
        1) When MT-RJ adapters are used, adapter shall be a style that has a polarity adjustment knock-out keyway tab that shall be oriented on inside of panel so that it is not accessible to user once system is installed.
4. Capable of being used with field-installable connectors or in applications where preconnectorized cables are routed directly from equipment to interconnect hardware.
5. Capable of accepting interchangeable connector panel.
6. Panel shall be attached with two push-pull latches to allow quick installation and removal.
7. Blank Connector Panel:
    a. Available to fill unused space within housing.
    b. Attached with at least two push-pull latches to allow quick installation and removal.
    c. Manufactured from injection-molded polycarbonate.

B. Pigtailed Adapter Panels:

1. Manufactured from 16-gauge cold rolled steel or injection-molded polycarbonate for structural integrity.
2. Attached with two push-pull latches to allow quick installation and removal.
3. Use for splicing preterminated pigtails to field cables.
    a. Pigtails shall be bundled in a MIC or Ribbon style subunit.
    b. Pigtail Length: 3 meters.
4. Offered in 6-fiber, 8-fiber, 12-fiber, 16-fiber, and 24-fiber versions.
    a. 6-fiber panels shall be offered in ST compatible, FC, SC simplex.
    b. 8-fiber and 12-fiber versions shall include ST compatible connector, FC, LC duplex, SC duplex and simplex and MT-RJ multifiber connectors.
    c. For high-density applications, MT-RJ and LC duplex panels shall be available in 16-fiber and 24-fiber versions.

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1) When MT-RJ adapters are used, adapter shall be a style that has a polarity adjustment knock-out keyway tab that shall be oriented on inside of panel so that it is not accessible to user once system is installed.

d. Each individual fiber shall be color coded in accordance with TIA 598.

C. Manufacturers: Reference Contract Drawings and Section 40 94 13, Digital Process Control Computers, Supplement 01 Network Hardware Equipment List.

2.08 CONNECTORS

A. General:

1. Comply with TIA/EIA 604-2, TIA/EIA 604-3, TIA/EIA 604-12, and TIA 568-C.3.
2. LC connectors preferred unless otherwise required for SC and ST ancillary devices.
3. Pull Strength: 0.2 N minimum.
4. Durability: Sustain minimum 500 mating cycles without violating other requirements.
   a. Ferrules: Free-floating low loss ceramic.
   b. Polarizing key on duplex connector systems.
5. Attenuation:
   a. In accordance with TIA 568-C.3.
   b. Maximum of 0.75 dB per connector pair.
6. Manufacturer:
   a. Corning Cable Systems; Unicam.
   b. Leviton; FastCAM.
   c. Black Box.

2.09 PATCHCORDS

A. General:

1. In accordance with TIA 568-C.3.
2. Function: Connect fiber centers to network nodes, such as computer workstations.
3. Fiber Characteristics: In accordance with requirements for fiber optic cable.
4. Cable Configuration:
   a. Individual tight-buffer thermoplastic, fibers single or multimode, to match fibers being jumpered on.
   b. Protected with kevlar strength members and enclosed in thermoplastic jacket.

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5. Length: Standard, to meet requirements shown, plus minimum 3 meters at workstations.
6. Connectors:
    a. As required by Article Connectors.
    b. On-axial Pull Strength: 33 N.
    c. Normal-to-Axial Pull Strength: 22 N.
7. Cable Rating: OFNR or OFNP.
8. Color: Per standards or as indicated.
9. Measured for insertion loss with the following values for each connector:
    a. Typical of 0.3 dB and maximum of 0.5 dB (LC typical of 0.1 dB and maximum of 0.3 dB).

2.10 COMMUNICATIONS MANAGEMENT OUTLETS

A. General:

1. In accordance with TIA 568-C.3.
2. Function: Provide organized system for connecting workstations into precabled communications.

B. Cover Plates:

1. Flush and extension mount, as required to provide bend radius and space for coiled cable.
2. Materials: ABS plastic.
3. Color: White, unless otherwise indicated.
4. Identifiers: Color-coded identification strips.

C. Connectors:

1. Type: LC connectors preferred unless otherwise required for SC and ST ancillary devices.
2. Mounting: Face flush mount and Side for ow profile applications.

D. Manufacturers and Products:

1. Leviton; QuickPort wiring systems.
2. Panduit; CJ6X88 series wiring systems.
3. Hubbell; Premise wiring systems.

2.11 CONDUIT

A. In accordance with Section 26 05 33, Raceway and Boxes.

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2.12 ACCESSORIES

A. Hardware: Provide cable clamps, strain reliefs, blocking and grommet kits, closures, and fan outs for complete installation.

PART 3 EXECUTION

3.01 PREPARATION

A. Conduit:

1. Ensure installed conduit system conforms to fiber optic system requirements, including:
   a. Conduits and Innerducts: Size and number.
   b. Access Holes, Handholes, and Pull Boxes: Location and size, to ensure cables and innerducts may be installed without exceeding manufacturer's limitations.
   c. Outlet Boxes: Size to coordinate with outlet cover plates for adequate volume and bend radius.
2. Spare Conduit:
   a. No cables shall be pulled into spare conduit.
   b. 100 percent spare conduit capacity required for buried conduit only. For example, for every conduit with one or more cables in it, there shall be one spare equal-size conduit with no cables.
3. Expansion Plugs: Seal conduit to stop ingress of water and grit with fabricated expansion plugs.
4. Ensure duct bank, conduit, and other confined routing is free and clear of debris before cable placement.

B. Innerduct:

1. In accordance with manufacturer's recommendations.
2. In all fiber optic conduits.
3. Install no more than one innerduct of each color in single conduit.
4. Terminate innerducts in conduit with fabricated termination kits.
5. Identify innerducts at both ends by methods such as color-coding or waterproof tags wired through innerduct wall.
6. Sealing:
   a. Cabled Innerducts: Seal cables into innerducts to stop ingress of water and grit with fabricated expansion seals that have separate seals for each cable.
   b. Innerduct to Conduit: Seal gaps between innerducts and conduit with sealing compound such as 3M Ductseal.
   c. Empty Innerducts: After installation, seal with fabricated expansion plugs to stop ingress of water and grit. Remove plugs as required to install cables.

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3.02 INSTALLATION

A. Fiber Optic Cable:

1. Specified fiber counts, routing, origination, and terminating points are indicated on Drawings.
2. Installation by manufacturer's certified installer.
3. Install cables in accordance with manufacturer's requirements.
4. Install cable directly from shipping reels. Ensure that cable is:
    a. Not dented, nicked, or kinked.
    b. Not subjected to pull stress greater than manufacturer's specification.
    c. Not bent to a radius below manufacturer's minimum bend radius.
    d. Not subjected to treatment that may damage fiber strands during installation.
5. Cables per Conduit or Innerduct: One cable maximum. In accordance with NFPA 70 NEC conduit fill limitations.
6. If calculation indicates cable will attenuate signals more than 8 dB, reroute may be allowed if approved by Engineer.
7. Connector: Insertion loss on multimode connections exceeding 0.5 dB and 0.4 dB on single-mode connections not permitted.
8. Identification:
    a. Identify cable on both ends, in access holes, and pull points.
    b. In accordance with TIA 606.
9. Arrange cable, equipment, and hardware to provide neat appearance and accessibility for servicing.
10. Access Holes:
    a. Provide supports for cables in access and handholes at minimum 30-inch centers along sides.
    b. While maintaining minimum bend radius, lace cables neatly to supports to keep them out of way of personnel.

B. Fiber Center, Fiber Distribution Frame, Housing, Panel, Splice Tray: Install securely in field panels or enclosures as shown on Drawings.

C. Cable Terminations:

1. In accordance with TIA 568-C.3.
2. Fan out fiber cable to allow direct connectorization of connectors.
    a. Sleeve over individual fibers with transparent furcation tubes.
    b. At point of convergence of furcation tubes, provide strain relief with metal or high density plastic fan-out collar.
3. Break-out Kits:
    a. Terminate cables using manufacturer-supplied break-out kits.
    b. Terminate in accordance with manufacturer's recommendations.

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4. Slack:
    a. Fiber Centers, Hubs, and Switches: Minimum, 3-meter slack fiber at each end, coiled neatly in cable management equipment.
    b. Communications Management Outlets: Minimum, 1-meter slack fiber, coiled neatly in outlet box.
5. Connectors:
    a. Terminate 100 percent fibers in each cable to specified connector.
    b. Connect into fiber management system.

D. Ethernet Fiber-to-Copper Transceivers:

1. Install transceivers in accordance with manufacturer's instructions.
2. Location: Install transceivers securely in field panels, close to network nodes and fiber centers.
3. Power: Energize each transceiver from its field panel's UPS, if applicable.
4. Connections:
    a. Connect transceiver to fiber optics and network node.
    b. Lace fiber optics neatly in place, routed through wireways.

E. Conduit: Install in accordance with Section 26 05 33, Raceway and Boxes.

3.03 LABELING CONVENTIONS

A. Conform to TIA 606 or to requirements specified by CH2M HILL or CH2M HILL's representative.

B. Backbone (Riser) Cables:
1. Multiconductor cables connecting main distribution field to an intermediate distribution field, usually a wiring closet or cabinet, and are labeled at each terminating end. Label name identifies each endpoint, cable medium, and number of conductors as follows:
    a. Copper: IDF-MDF-C-PPP-N.
    b. Fiber: IDF-MDF-F-MMM, SSS-N.

Where:

IDF	Is the 3-5 position IDF/wiring closet/building code
MDF	Is the 3-5 position MDF (or IDF) code
F	Fiber
PPP	Is pair count of a copper cable
MMM	Is multimode strand count
SSS	Is single-mode strand count
N	Is a sequential number

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C. Horizontal (Station) Cables:

1. Connect jack stations to wiring closets or cabinets and are labeled at each end to identify wiring closet they connect to and sequential jack station number as follows:
   a. Data: IDF-D-NNN-A/B.
   b. Voice: IDF-V-NNN-A/B.

   Where:

IDF	Is the 3-5 position IDF/wiring closet/building code
D	Data cable (green)
V	Voice cable (gray)
NNN	Is the sequence number
A/B	Indicates left or right port in faceplate

3.04 FIELD QUALITY CONTROL

A. General:

1. Advise Engineer at least **[A: 24] [B: 48] [C:]** hours in advance of each test. Engineer shall have option to witness and participate actively in tests.
2. In accordance with Section 01 91 14, Equipment Testing and Facility Startup.
3. Provide equipment, instrumentation, supplies, and skilled staff necessary to perform testing.
4. Outlets, cables, patch panels, and associated components shall be fully assembled and labeled prior to field testing.
5. Testing performed on incomplete systems shall be redone on completion of the Work.
6. Document Test Results:
   a. Confirm each cable has at least specified number of fibers that meet standards, in accordance with As-Built Fiber Optic Cable Installation form included as Supplement to this section.
7. Confirm quantities and sizes of conduit and innerduct, in accordance with As-Built Conduit/Innerduct Installation form included as Supplement to this section.

B. Test Equipment:

1. Field test instruments shall have latest software and firmware installed.
2. Optical Fiber Cable Testers:
   a. Field test instrument shall be within calibration period recommended by manufacturer.

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b. Optical Loss Test Set (OLTS):
    1) Single-mode Optical Fiber Light Source:
        a) Provide dual laser light sources with central wavelengths of 1,310 nm (plus or minus 20 nm) and 1,550 nm (plus or minus 20 nm).
        b) Output Power: Minus 10 dBm, minimum.
        c) Manufacturer: Fluke Networks.
    2) Multimode Optical Fiber Light Source:
        a) Provide dual LED light sources with central wavelengths of 850 nm (plus or minus 30 nm) and 1,300 nm (plus or minus 20 nm).
        b) Output Power: Minus 20 dBm minimum.
        c) Meet launch requirements of TIA/EIA 455-78. This launch condition can be achieved either within the field test equipment or by use of an external mandrel wrap, as described in Clause 11 of TIA 568-C.3, with Category 1 light source.
        d) Manufacturer: Fluke Networks.
    3) Power Meter:
        a) Provide 850 nm, 1,300/1,310 nm, and 1,550 nm wavelength test capability.
        b) Power Measurement Uncertainty: Plus or minus 0.25 dB.
        c) Store reference power measurement.
        d) Save at least 100 results in internal memory.
        e) PC interface (serial or USB).
        f) Manufacturer: Fluke Networks.
    4) Optional Length Measurement: Capable of measuring optical length of fiber using time-of-flight techniques.

3. Optical Time Domain Reflectometer (OTDR):
    a. Bright, color transmissive LCD display with backlight.
    b. Rechargeable for 8 hours of normal operation.
    c. Weight with battery and module of not more than 4.5 pounds and volume of not more 200 cubic inches.
    d. Internal nonvolatile memory and removable memory device with at least 16 MB capacity for results storage.
    e. Serial and USB ports to transfer data to PC.
    f. Single-mode OTDR:
        1) Wavelengths: 1,310 nm (plus or minus 20 nm) and 1,550 nm (plus or minus 20 nm).
        2) Event Dead Zone: 2 meters maximum at 1,310 nm and 2 meters maximum at 1,550 nm.
        3) Attenuation Dead Zone: 15 meters maximum at 1,310 nm and 15 meters maximum at 1,550 nm.
        4) Distance Range: Minimum 10,000 meters.

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5) Dynamic Range: Minimum 10 dB at 1,310 nm and 1,550 nm.

g. Multimode OTDR:

1) Wavelengths: 850 nm (plus or minus 20 nm) and 1,300 nm (plus or minus 20 nm).
2) Event Dead Zone: 1 meter maximum at 850 nm and 2 meters maximum at 1,300 nm.
3) Attenuation Dead Zone: 6 meters maximum at 850 nm and 15 meters maximum at 1,300 nm.
4) Distance Range: 2,000 meters minimum.
5) Dynamic Range: Minimum 10 dB at 850 nm and 1,300 nm.

h. Manufacturer: Fluke Networks.

4. Fiber Microscope:
   a. Magnification: 250X or 400X for end-face inspection.
   b. Manufacturer: Fluke Networks.
5. Integrated OLTS, OTDR, and Fiber Microscope:
   a. Test equipment that combines into one instrument such as OLTS, OTDR, and fiber microscope may be used.
   b. Manufacturer: Fluke Networks.

C. Conduit Test:

1. Test and seal spare conduits.
2. Conduit and Innerduct Testing:
   a. Blow full-diameter mouse through each spare conduit and innerduct to verify they are unrestricted over full length.
   b. If conduit is restricted over full length, advise Engineer.
3. Documentation: Confirm conduit test As-Built Conduit/Innerduct Installation form documentation includes details of innerducts.

D. Cable Testing:

1. Test procedures and field test instruments shall comply with applicable requirements of:
   a. LIA Z136.2.
   b. TIA/EIA 455-78.
   c. TIA/EAI 455-133.
   d. TIA 526-7.
   e. TIA 526-14.
   f. TIA 568-C.1.
   g. TIA 568-C.3.
   h. TIA TSB 140.
2. Test attenuation and polarity of installed cable plant with OLTS and installed condition of cabling system and its components with OTDR.
3. Verify condition of fiber end face.
4. Perform on each cabling link (connector to connector).

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5. Perform on each cabling channel (equipment to equipment).
6. Do not include active devices or passive devices within link or channel other than cable, connectors, and splices. For example, link attenuation does not include such devices as optical bypass switches, couplers, repeaters, or optical amplifiers.
7. Document Tests:
    a. OLTS dual wavelength attenuation measurements for single-mode and multimode links and channels.
    b. OTDR traces and event tables for single-mode and multimode links and channels.

E. Fiber Testing Parameters:

1. Each cabling link shall be in compliance with the following test limits:
    a. Optical Loss Testing:
        1) Backbone (single-mode and multimode) Link:
            a) Calculate link attenuation by the formulas specified in TIA 568-C.1.
            b) Values for Attenuation Coefficient (dB/km) are listed in the table below:

Attenuation Coefficient				
Type of Optical Fiber	**Wavelength (nm)**	**Attenuation Coefficient (dB/km)**	**Wavelength (nm)**	**Attenuation Coefficient (dB/km)**
Multimode 62.5/125 µm	850	3.5	1300	1.5

    b. OTDR Testing:
        1) Reflective Events: Maximum 0.75 dB.
        2) Nonreflective Events: Maximum 0.3 dB.
    c. Magnified Endface Inspection:
        1) Visually inspect fiber connections for end-face quality.
        2) Scratched, pitted, or dirty connectors shall be diagnosed and corrected.

F. Diagnosis and Correction:

1. Installed cabling links and channels shall be field tested and pass test requirements and analysis as described herein.
2. Link or channel that fails these requirements shall be diagnosed and corrected.
3. Document corrective action and follow with new test to prove corrected link or channel meets performance requirements.
4. Provide final and passing result of tests for links and channels.

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G. Acceptance: Acceptance of test results shall be given in writing after Project is tested and completed in accordance with Contract Documents and satisfaction of CH2M HILL.

H. Test Execution:

1. Optical Fiber Cable Testing:
    a. Tests performed that use laser or LED in test set shall be carried out with safety precautions in accordance with LIA Z136.2.
    b. Link and channel test results from OLTS and OTDR shall be recorded in test instrument upon completion of each test for subsequent uploading to a PC in which administrative documentation may be generated.
        1) Record end-face images in memory of test instrument for subsequent uploading to a PC and reporting.
    c. Perform Testing:
        1) On each cabling segment (connector to connector).
        2) On each cabling channel (equipment to equipment).
        3) Using high-quality test cords of same fiber type as cabling under test.
            a) Test cords for OLTS testing shall be between 1 meter and 5 meters in length.
            b) Test cords for OTDR testing shall be approximately 100 meter for launch cable and at least 25 meters for receive cable.
2. Optical Loss Testing (OLTS):
    a. Backbone Link:
        1) Test single-mode at 1,310 nm and 1,550 nm in accordance with TIA 526-7, Method A.1, One Reference Jumper or equivalent method.
        2) Test multimode at 850 nm and 1,300 nm in accordance with TIA 526-14A, Method B, One Reference Jumper or equivalent method.
        3) Perform tests in both directions.
3. OTDR Testing:
    a. Test backbone, horizontal, and centralized links at appropriate operating wavelengths for anomalies and to ensure uniformity of cable attenuation and connector insertion loss.
        1) Single-mode: 1,310 nm and 1,550 nm.
        2) Multimode: 850 nm and 1,300 nm.
    b. Test each fiber link and channel in one direction.
    c. Install launch cable between OTDR and first link connection.
    d. Install receive cable after last link connection.
4. Length Measurement:
        1) Record length of each fiber.
        2) Measure optical length using OLTS or OTDR.

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5. Polarity Testing:
    a. Test paired duplex fibers in multifiber cables to verify polarity in accordance with subclause 10.3 of TIA/EIA 568-C.1.
    b. Verify polarity of paired duplex fibers using OLTS.
6. Test Results Documentation:
    a. Test results saved within field-test instrument shall be transferred into Windows-based database utility that allows for maintenance, inspection, and archiving of test records. These test records shall be uploaded to the PC unaltered. For example, “as saved in the field-test instrument.” The file format, CSV (comma separated value), does not provide adequate protection of these records and shall not be used.
    b. Available for inspection by Owner or Owner’s representative during installation period. Submit within 5 working days of completion of tests on cabling served by a telecommunications room or of backbone cabling.
    c. Database for project, including twisted-pair copper cabling links, if applicable, shall be stored and delivered on CD-ROM prior to CH2M HILL acceptance of building. CD-ROM shall include software tools required to view, inspect, and print test reports.
    d. Circuit IDs reported by test instrument shall match specified label identification.
    e. Provide in electronic database for each tested optical fiber with the following information:
        1) Identification of Site.
        2) Name of test limit selected to execute stored test results.
        3) Name of personnel performing test.
        4) Date and time test results were saved in memory of tester.
        5) Manufacturer, model, and serial number of field test instrument.
        6) Version of test software and version of test limit database held within test instrument.
        7) Fiber identification number.
        8) Length for Each Optical Fiber: Optionally the index of refraction used for length calculation when using a length capable OLTS.
        9) Test results to include OLTS attenuation link and channel measurements at appropriate wavelength and margin; difference between measured attenuation and test limit value.
        10) Test results to include OTDR link and channel traces, and event tables at appropriate wavelength.
        11) Length for each optical fiber as calculated by the OTDR.
        12) Overall pass/fail evaluation of link-under-test for OLTS and OTDR measurements.

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I. Drawings:

1. Record Copy: Provide at end of Project on CD-ROM.
   a. CAD format and include notations reflecting as-built conditions of additions and variations from Drawings provided, such as to cable path and termination point.
   b. CAD drawings are to incorporate test data imported from test instruments.
2. As-built Drawings:
   a. Include, but not limited to block diagrams, frame and cable labeling, cable termination points, equipment room layouts, and frame installation details.
   b. Include field changes made up to construction completion:
      1) Field directed changes to pull schedule.
      2) Field directed changes to cross connect and patching schedule.
      3) Horizontal cable routing changes.
      4) Backbone cable routing or location changes.
      5) Associated detail drawings.

3.05 TRAINING

A. Train Owner's staff in the following skills:

1. Connectorizing fibers.
2. Splicing optical fiber cables, including fiber splices.
3. Testing quality of connectors, splices and fibers.

B. Materials: Provide hardware for training, including fibers, connectors, and splice kits.

3.06 SUPPLEMENTS

A. Supplements listed below, following "End of Section," are part of this Specification.

1. As-Built Fiber Optic Cable Installation Form.
2. As-Built Conduit/Innerduct Installation Form.

END OF SECTION

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PROJECT: Cutter Lateral Water Treatment Plant

Contractor:

Signed by:

AS-BUILT FIBER OPTIC CABLE INSTALLATION

Cable Identification:
Routing: From: In:
(Identify field panel, control room, etc. in building)

Through: 1
(Identify access hole, building, gallery, etc.)
Through: 2 Through: 5
Through: 3 Through: 6
Through: 4 Through: 7
To: In:
See As-Built Conduit/Innerduct Installation forms for identification of conduits/innerducts cable is routed through.

Acceptable Attenuation:
Multimode Fibers

		cable length*	
850 nm:	3.5 dB/km x	km + 1.5 dB =	dB
1300 nm:	1.0 dB/km x	km + 1.5 dB =	dB

*Contractor to provide actual length installed, within ±0.1 km.

Fiber ID	Use/Spare	Measured Attenuation (dB)			
		Hub-to-Node		Node-to-Hub	
		850 nm	1,300 nm	850 nm	1,300 nm

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Single-mode Fibers

		cable length*	
1310 nm:	**1.0 or 0.5** dB/km x	km + 1.5 dB =	dB
1550 nm:	**1.0 or 0.5** dB/km x	km + 1.5 dB =	dB

*Contractor to provide actual length installed, within ±0.1 km.

Fiber ID	Use/Spare	Measured Attenuation (dB)			
		Hub-to-Node		Node-to-Hub	
		1,310 nm	1,550 nm	1,310 nm	1,550 nm

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PROJECT: Cutter Lateral Water Treatment Plant

Contractor:

Signed by:

AS-BUILT CONDUIT/INNERDUCT INSTALLATION

From: To:

(Identify building, access hole, field panel, etc.) Sheet 1 of 1

Conduits:
Used: 4 inches; 2 inches
Spare: 4 inches; 2 inches Confirm all spares unrestricted: Yes/No
(Provide number of conduits in each category)

Innerducts:

Conduit ID*	Innerduct ID	Cable ID / Spare

(Continued overleaf delete if not applicable)

*Provide conduit ID if required to identify innerduct uniquely in the access hole, if for example, color-coded innerduct is used in more than one conduit. If innerducts are tagged uniquely, leave this column blank.

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SECTION 40 96 00
APPLICATIONS SOFTWARE

PART 1 GENERAL

1.01 WORK INCLUDED

A. General: Work includes design, furnishing, testing, documenting, training and starting up the Process Instrumentation and Control (PIC) Applications software, complete for Facilities.

B. Objective: Owner PLC and HMI standard software includes: Schneider Electric Unity Pro XL software for PLC programming and Schneider Electric Citect Viejo software for SCADA programming at the Cutter Lateral WTP. Standardized Software operates on Microsoft Windows 7 Operating System (OS). The objective of this section is to coordinate, develop, revise, implement, test and document all PLC and SCADA programming for the Project.

C. Major applications software work items include:

1. Work sequence and schedule.
2. Applications software workshops.
3. Applications software submittals.
4. Applications software development.
5. Documentation and generation of as-built revisions to Plant PLC and SCADA development standards.
6. Software maintenance and installation.
7. O&M development.
8. Owner and Operator training.
9. Startup and Testing.

D. SCADA Development: Assume the following minimum level of SCADA HMI development for Facilities:

1. New SCADA Level 1 Plant Overview Displays: 1.
2. New SCADA Level 2 Unit Operation Overview Displays: X.
3. New SCADA Level 3 Control Displays: X.
4. New SCADA Level 4 Data Entry Displays: X.
5. New SCADA Level 1 Communication (PLC) Overview Diagrams: 1.
6. New SCADA Level 2 Communication (PLC) Diagrams: 1.
7. New Process Alarms: Based upon Loop Descriptions and IO Listing.
8. New Process Trends: Based upon Loop Descriptions and IO Listing.
9. New Process Tags: Based upon Loop Descriptions and IO Listing.

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1.02 DIVISION OF WORK

A. Contractor: The Contractor shall have overall system responsibility and shall provide all additional materials and work necessary to satisfy all requirements of this section.

B. New Control Panels with new PLCs provided and programmed under Section 40 90 00, Instrumentation and Control for Process Systems, include:

1. **[A: .]**

C. Package Control System provided under Section 40 99 90, Package Control Systems include:

1. Sludge Collection PLC; Reference Section 44 46 10, Sludge Collection Equipment.

1.03 DEFINITIONS

A. Abbreviations:

1. I&C: Instrumentation and Control.
2. I/O: Inputs and Outputs.
3. O&M: Operation and Maintenance.
4. Functional Test: Operational Readiness Test.
5. P&ID: Process and Instrument Diagram.
6. PC: Personal Computer.
7. PIC: Process Instrumentation and Control.
8. PLC: Programmable Logic Controller.
9. PT: Performance Testing.
10. SCADA: Supervisory Control System (i.e., Schneider Electric Citect Viejo).
11. SSDT: Staging Site Demonstration Test (Hardware and Software).
12. SLC: Single Loop Controller.

B. Instructor Day: 8 hours of actual instruction time.

C. Loop Specifications: Lists and descriptions in Supplement 1, Loop Descriptions, of Section 40 90 00, Instrumentation and Control for Process Systems, give additional requirements for individual control loops.

D. Software:

1. Programming of digital devices using all types of programming language.
2. Configuring of digital devices using all types of configuring process.

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3. Programs or configuration data stored in read only memory, programmable read only memory, read/write memory, disk, tape, or other storage device.

E. Types of Software:

1. Standard Software: Software package that is independent of project on which they are used. Standard software includes system software and process monitoring and control software.
   a. System Software: Application independent software developed by Microsoft. Includes, but is not limited to, Microsoft's NT operating system; file management utilities; text editors; debugging aids; and diagnostics.
   b. SCADA: Software packages independent of specific process control project on which they are used. Includes, but is not limited to, providing capability for, data acquisition, monitoring, alarming, man-machine interface, data collection, data retrieval, trending, report generation, control, and diagnostics.
2. Application Software:
   a. Software to provide functions unique to this Project and that are not provided by standard software alone.
   b. Configuring databases, tables, displays, reports, parameter lists ladder diagrams, function block, and control strategies required to implement functions unique to this Project.

1.04 WORK SEQUENCE AND SCHEDULE

A. General: All work provided under this section shall be in accordance with a Milestone Breakdown and System Delivery Plan.

B. Milestone Breakdown (MB): Summarize the major milestones for work provided along with the major milestones of the Project.

C. System Delivery Plan (SDP):

1. The intent of the SDP is to:
   a. Coordinate and communicate applications software design and testing activities.
   b. Coordinate interactions with the Owner regarding workshops, submittal reviews, contractor(s) progress, test witnessing, training, etc.
   c. Communicate and clarify required work sequences and major milestone.
2. Minimum Content:
   a. Work sequence and schedule.
   b. Applications software workshops.
   c. Applications software submittals.

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d. Applications software development.
e. Software testing.
f. Software installation.
g. O&M development.
h. Owner training.
i. Startup.

1.05 SOFTWARE DESIGN WORKSHOPS

A. Location: Owner's facility during the course of the Project.

B. Objective: To provide a vehicle for the Owner to oversee the applications software development.

C. Documentation: PIC Integrator summarizes resolutions reached in each workshop, including cost and schedule impacts and distributes copies to Owner and Engineer.

D. Order and minimum topics to be covered in each Software Design Workshop.

1. Loop Specifications, P&ID Review Workshop:
   a. PIC Integrator use P&IDs and Loop Specifications to present how the proposed control system design and Applications Software will meet the functional requirements specified herein.
   b. At the completion of workshop, Applications PIC Integrator updates Loop Specifications with changes, additions and clarifications, using revision modes, that documents the changes.
   c. Submit finalized Loop Specification along with an outline of any application software cost and schedule impacts.
2. Update PLC Standards Software Workshop: PLC Software Standards shall be updated (as-built) in a Software Standards Workshop. Ladder diagram standards for commonly used functions, including the following:
   a. Objective: Update PLC Software Standards.
      1) PLC Hardware, Central Processing Unit (CPU) Modules, Redundant Systems and Redundancy Modules, Communications Modules, Input/output Modules, Power Supplies, and Chassis for large and small platforms.
      2) PLC Programming Structure, Database, Data Types, Memory Mapping, and Tagnaming Conventions.
      3) PLC Ladder and Function Block Standard Programming implementing.
      4) Process Equipment Start/Stop, Alternating, Backup, Lead/Lag Controls.
      5) PID Auto-Manual, Feed-Forward, Cascade, Trim, and Anti-windup.

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6) Valve Control Open-Close-Stop, Position, Modulation.
7) Analog Input Signal Scaling and Alarming.
8) Analog and Digital Alarms Timers.
9) Flow and Runtime Totalization.
10) Process Equipment Startup and Shutdown Sequence.
11) Process Equipment Failure.

3. Update SCADA Standards Workshop: SCADA Software Standards shall be updated (as-built) in a Software Standards Workshop.
   a. Objective: To update SCADA standards in a participative workshop with Owner.
   b. Design products and topics to be updated:
      1) SCADA integration.
      2) Tag Group naming convention.
      3) SCADA tag naming conventions.
      4) Overview display design.
      5) Process graphics.
      6) Display paging and navigation.
      7) Dynamic Objects: Pumps, valves, gates, compressors, etc.
      8) Equipment control through pop-up windows.
      9) Loop control through pop-up windows.
      10) Display philosophy, organization and operation.
      11) General data entry through the SCADA.
      12) Use of tool tips.
      13) Color graphic standards, symbol standards, etc.
      14) Dynamic Objects: Pumps, compressors, valves, gates, controller faceplates, process indicators, indicators with alarms, data entry, controller face plate, dampers, aerator, chemical feed pump, mixers.
      15) Security.
      16) Alarm Management: Operation of the alarms, alarm areas, alarm filtering.
      17) Trending.
      18) Historical data storage and retrieval.
      19) Variable naming conventions.
      20) Scripting.
      21) Tag Group files naming convention.
      22) Display files naming convention.
4. Plant Process Reporting Workshop:
   a. Objective: Coordinate and document number and types of Reports to be provided by Owner as Part of **[A: .]**
   b. Identify with Owner each possible type of Process report including:
      1) Daily flow for each chemical pump (chemical usage), process flow, major motor load, switchboard, and MCC assembly providing power input.

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2) Weekly flow totals each chemical pump (chemical usage), process flow, major motor load, switchboard, and MCC assembly providing power input.
3) Monthly flow totals each chemical pump (chemical usage), process flow, major motor load, switchboard, and MCC assembly providing power input.
4) Yearly flow and totals each chemical pump (chemical usage), process flow, major motor load, switchboard, and MCC assembly providing power input.

c. Identify and define each type of Process Alarm report including:
1) Daily severity or priority level (1) and (2) critical alarm input.

d. Identify and define each type of Process Status report including:
1) Daily equipment runtime, process pressure, analytical, and liquid level.
2) Weekly process pressure, analytical, and liquid level.
3) Monthly process pressure, analytical, and liquid level.
4) Yearly process pressure, analytical, and liquid level.

5. Pre-software Development Workshops:
a. Objective: To present to Engineer and Owner how Applications PIC Integrator will implement functional requirements of this section.
b. Present information on:
1) Program Flow Diagram(s) showing all software sections, subsections, function- blocks, subprograms, and their interrelationships.
2) SCADA/PLC I/O Database listing.
3) SCADA Screen sketches that illustrate dynamic objects, how control functions are controlled and monitored, how equipment is controlled and SCADA screen navigation.

6. PLC and SCADA Development Workshops:
a. Objective: To present to Engineer and Owner software development prior to Factory and Functional Testing and Startup.
b. Present Information On:
1) PLC programmed Logic (Function Block, Diagram, Ladder) and documentation for major and similar processes.
2) HMI Display Screen and Scripting for various major and similar processes.
3) Display navigations and communications.

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1.06 SUBMITTALS

A. Action Submittals:

1. Loop Specification and P&ID Submittals:
   a. Timing: Following P&ID and Loop Description Workshop.
   b. Content: Updated version of Loop Specifications.
2. Process Reports Submittal:
   a. Timing: Following Reports Workshop.
   b. Content: Document and submit Reports criteria and functional requirements.
3. Updated (as-built) PLC Software Standards Submittals:
   a. Review and update PLC Standards in a Software Workshop, Documented and Submitted as Updated PLC software standards.
4. Updated (as-built) SCADA Standards Submittal:
   a. Review and update SCADA standards in a participative workshop with the Owner.
   b. Documented and submitted as Updated SCADA software standards.
5. Pre-software Development Submittal: Updated version of material presented in Pre-software Development workshop.
6. Software Design Submittal: Detailed description of SCADA Configuration and PLC program on a Unit Operation Basis. Submit this during program development stage.
   a. An updated version of all information presented in Pre-software Development Submittal.
   b. Documented PLC Program.
   c. Print out of SCADA screens.
7. Software Standard Submittals: Draft and Final Plant Updated PLC and SCADA Development Standards.

B. Informational Submittals:

1. Applications Software Schedule of Values and Progress Schedule:
   a. Submit within 30 days after first Preconstruction Conference.
   b. Upon acceptance by Engineer, shall form basis and schedule of Submittal reviews, test witnessing, and partial payments.
   c. Prior to this acceptance, Engineer will not review Submittals, witnesses tests, or consider requests for partial payment.
2. Owner Training Plan: In accordance with Section 01 79 20.

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3. Testing Related Submittals:
    a. Test Forms:
        1) Proposed test procedures, forms, and check lists:
            a) Factory Demonstration Testing including Software Demonstration Testing.
            b) Functional Acceptance Tests.
            c) Performance Acceptance Test (PAT).
    b. Test Procedures: Conduct tests using Engineer accepted test procedures, forms, and checklists.
    c. Test Documentation: Copy of signed of test procedures when tests are completed.
4. Operations and Maintenance Manuals:
    a. In accordance with Section 01 78 23, Operation and Maintenance Data, unless otherwise specified in this section.
        1) User's manuals for Standard Software packages.
        2) Licensed copies of Standard Software packages (i.e. HMI "Client").
        3) Updated versions of material provided under Shop Drawing Submittals for Applications Software Design and Development.
        4) Applications software source files.

PART 2 PRODUCTS

2.01 PLC APPLICATION SOFTWARE DESIGN CRITERIA

A. PLC Program Design:

1. The programmable logic controller system (PLC) shall be used to provide facility automatic control, alarm functions (annunciator), and continuous loop control. Specific PLC functional requirements are described in the loop specifications.
2. No control routines, control algorithms, or control logic shall be implemented in the SCADA.
3. Break PLC applications software into:
    a. Sections:
        1) Contains all logic for a specific unit operation.
        2) Each section consists of a general logic subsections and, followed by unit operation subsections.
    b. Subsections: Contains logic for specific equipment such as a pump, valve or loop.
    c. Functional Blocks:
        1) Building block for pumps, valves, loop control, analog processing, and alarm switches.
        2) Requirements for standard SCADA/PLC function blocks to be provided are specified herein.

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4. Program Documentation:
    a. Note and describe start of a new program section.
    b. Briefly describe control objectives.
    c. Identifies subsections.
    d. Subsection documentation includes brief description of control objective followed by a description and tag of the equipment being controlled.

2.02 SCADA APPLICATION SOFTWARE DESIGN REQUIREMENTS

A. General:

1. The Applications PIC Integrator shall develop the SCADA design to convey accurate information to the plant operations staff so they can make informed process control decisions and provide the platform to execute the control decisions.
2. The following outlines key objectives in designing the SCADA graphics displays:
    a. Easily navigated menus.
    b. Provide no more than three mouse actions to navigate to any control display.
    c. Maintain consistency in graphic display and controls design. (Consistency reduces the chances of misunderstanding, significantly reduces learning time, anxiety and stress.)
    d. Maintain consistent and predictable window operations.
    e. Accurate representation of the plant and its operations.
    f. Represent control options in an easily understood fashion.
    g. Develop help screens to provide additional information to help the operations staff understand the control options where complex operations are required.
    h. A pleasant and engaging interface that conforms to the operators “Mental Model”.
    i. Where possible, design overview displays similar to the physical layout of the facility. The perspective to the physical layout should be from the local main control room.
    j. Provide operator access to process and alarm setpoints, including the following:
        1) Process alarms (High-High, High, Low, and Low-Low).
        2) Pump and equipment control setpoints.
        3) Process timer setpoints.
        4) Sequence setpoints for volume, level, time etc.

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B. General Display Organizational Philosophy:

1. The process and control graphic display hierarchy consists of four levels of displays. The following briefly describes the intent of each of the four levels of displays:
    a. Level 1—Plant Overview(s):
        1) The Plant Overview(s) show major processes such as Primary, Secondary, and Anaerobic Treatment etc. These overview displays show the most important (essential) process data and major equipment status on a plant wide basis, but provide no equipment or system control.
        2) The Plant Overview(s) display provide the means to page (i.e., go to) to other Plant Overviews or Unit Process overviews, or in some cases directly to Control Displays.
        3) As a general rule, the Plant overviews show the most critical status and system data that give the operations staff a good general feel on how the plant, is currently operating. A Plant Overview is going to be the opening display whenever the SCADA is started.
    b. Level 2—Unit Process Overviews:
        1) Unit Process Overviews are full sized screens.
        2) The Unit Process Overviews show primary process data on unit processes, unit operations, equipment status, or system status, etc. As a general rule no control strategies are implemented through the Unit Operations Overviews. The unit operations overview provides the means to page to Control Displays.
        3) The general rule is to show enough status and system data information that gives operations staff a good general feel on how the individual processes are currently operating. It also provides a launching pad to access control information associated with the individual processes.
        4) Examples of Unit Process Overviews are Rapid Mix/Flocculation, Effluent Pump Station, Filtration, Chemical system.
    c. Level 3—Control Displays:
        1) Control Displays can be Full screen or popup windows.
        2) Control Displays provide the means to monitor and provide Supervisory Control of specific process operations such as pump stations, specific pumps, pH control, chemical systems, etc. Depending on the complexity of the specific process there may be several levels of displays.
            a) The Level display provides the capability to control specific equipment, system and to navigate directly to related displays.

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3) Supervisory Control:
   a) The objective of the SCADA design approach is to implement all Supervisory Control of the plant and its process and control strategies from the control displays. The control strategies include the following functions:
      (1) System level control, such as control loops, and sequences, etc.
      (2) Equipment level control, such as a pump start/stop control.
      (3) Detailed monitoring of sequence steps and general information messages for status.
      (4) Important alarm messages.
      (5) Paging between related displays.
      (6) Paging between related processes.
4) Pop-Up Windows:
   a) Pop-up windows provide the capability to control systems and equipment without cluttering the overview or control display. The following illustrates the configuration of a typical pop-up window.
5) Typical Pop-up Window:
   a) The typical pop-up window provides the following functions:
      (1) Status monitoring of equipment being controlled.
      (2) Operating mode.
      (3) Manual mode selection.
      (4) Start/Stop Control in Manual.
      (5) Auto mode selection.
      (6) Failure Reset.
      (7) Equipment description.
      (8) Control for displaying the equipment number.

d. Level 4—Data Entry and Trend Displays:
   1) Data Entry displays are designed especially for data entry purpose. Operators enter process setpoints, equipment control setpoints (such as lead-lag pump start/stop setpoints), alarm setpoints, etc. The following figure illustrates a typical data entry display.

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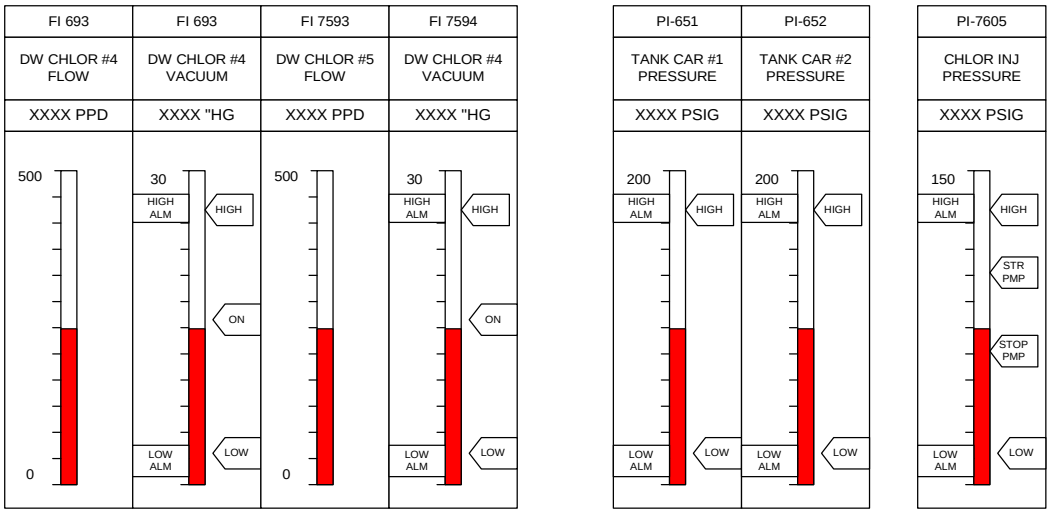
CHLORINATION MISCELLANEOUS INDICATORS AND SETPOINTS



Example Data Entry Display

The operator clicks on a setpoint pointer then enters the setpoint. The pointer is then scaled the same as the process variable.

e. Display Navigation:
   1) To provide fast and effective screen navigation shall be provided. The following outlines the type of screen navigation functionality to be provided. The final display navigation process shall be developed in the software workshops.

f. Main Directory:
   1) A Main Directory can be a list of Displays that shows the hierarchy of Plant Overviews, Unit Process Overviews, Control Displays and Data Entry Displays.
   2) The Main Directory provides a way to catalog and access all displays, however, is does not provide an effective navigation tool for plant operations.
   3) The Plant Overview Display is another type of Main Directory Display that has active areas (poke points) to call up Unit Process Displays based on physical location in the plant.
      a) The Main Directory Display lends itself to fast navigation from display to display.

g. Main Navigation Menu Bar: The Main Navigation Menu Bar is series of buttons on the bottom of each display that provides the user with the capability to go to (navigate to) any unit operation.
   1) The Main Navigation Menu Bar takes up graphic screen area on each full size screen but does provide a consistent, fast way to navigate between unit operation screens.

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h. Previous and Next Display Controls:
   1) Previous and Next display configurations shall be provided.
   2) The Next and Previous displays will be configured to operate within the same level. For example, if an operator is on a Level 2 unit process overview, the previous and next displays configuration will be set up to cycle between all the Level 2 unit process overview displays.
   3) If the user was in the Level 3 displays for a specific unit process the next and previous displays will be configured to cycle between all the Level 3 and Level 4 displays associated with the unit process overview.

i. System/Control Displays:
   1) Each Unit Process Display will have soft-keys that call up System/Control displays. If possible, develop soft-keys that call up system/control displays that use a transparent button over the unit. For example on the Thickening overview a transparent button over a specific gravity belt will call up the respective gravity belt control display.
   2) A transparent button is a control that has an outline of a button but is transparent. When placed over an object on a display, the object is still visible by clearly identifies navigation to another display or access to a pop-up window.

C. Alarm Group Display: The alarm group window gives operators a first-level indication of an alarm occurrence by group and allows operators to filter the alarm list. It indicates by solid color that an active (acknowledged) alarm exists in the alarm group and by blinking that an unacknowledged alarm exists in the alarm group.

D. Alarm Summary (Filtered): The Filtered Alarm summary window is dedicated to the presentation and acknowledgment of alarms. It provides alarm details, such as date and time of alarm, recurring alarm signal, alarm group, description of the alarm, alarm priority, current value, engineering unit, etc. for all alarms, acknowledged or unacknowledged. Once the alarms occur, they can be taken off the alarm list only if they have been acknowledged and the alarm conditions are no longer true.

2.03 SCADA/PLC I/O DATABASE

A. SCADA/PLC I/O Database: The PIC Integrator shall provide a Database tool that has the following functions:

   1. Coordinate, manage and document all points SCADA database points including those communicated between the PLCs and SCADA.
   2. The database shall contain the entire field necessary to configure the various points including the following per point type:

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a. Discrete Point configuration: The PIC Integrator shall provide a SCADA/PLC Discrete Input/output (I/O) database of all the analog and discrete points that are communicated to and from SCADA. The list shall be configured on a Microsoft Excel or Access database. The I/O list includes the following fields.
   1) Loop Number.
   2) CITECT VIEJO Block Tag Number.
   3) CITECT VIEJO Block type.
   4) CITECT VIEJO SCADA node the point is assigned to.
   5) Attribute: further definition of the function of the point. The follow list the definitions:
      a) A(X): SCADA alarm read, where X designates the alarm priority: 1, 2, and 3.
      b) W: SCADA write to PLC register.
      c) R: SCADA read a PLC register.
      d) RW: SCC read and writes to PLC register.
   6) Point description.
   7) Alarm Description 1.
   8) Alarm Description 2.
   9) Closed Condition (INPUT): Description of the state of the input parameter of device when the field or internal PLC contacts are in the CLOSED position.
   10) Open Condition.
   11) Closed Condition (OUTPUT): Description of the output signal in the energized position.
   12) Alarm area.
   13) PLC NO: PLC number.
   14) PLC I/O: PLC I/O address.
   15) PLC coil number: The PLC register that the SCADA reads or writes to.

b. Analog Point Configuration: The PIC Integrator shall provide a SCADA/PLC Input/output (I/O) Database of all analog points that are communicated to and from the SCADA. The list shall be configured on a Microsoft Excel or Access database. The Analog I/O database includes the following fields:
   1) Loop Number.
   2) CITECT VIEJO Block Tag Number.
   3) CITECT VIEJO Block Type.
   4) CITECT VIEJO SCADA node the point is assigned to.
   5) Attribute that further defines of the function of the point. The following list the definitions: Note the attributes will be used of Functional Testing and development of the I/O driver configuration. New classification will be developed to meet the software needs.
      a) SPR: Setpoint read from PLC (floating point).
      b) SPW: Setpoint write to PLC (floating point).

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c) MNR: Output read from PLC (floating point).
d) MNW: Output writes to PLC (floating point).
e) PVR: Process variable read from PLC (floating point).
f) FPR: Floating Point Read (floating point).
g) FPW: Floating Point Write (floating point).
h) FQR: Flow totalizer read (Integer).
i) KTR: Equipment run time read (Integer).
j) IPR: Integer read (Integer).
k) IRW: Integer writes (Integer).

6) Point description.
7) Alarm Description 1.
8) Alarm Description 2.
9) Engineering units.
10) Scale range.
11) Alarms functions to be configured in CITECT VIEJO analog block configuration.
    a) High-High.
    b) High.
    c) Low.
    d) Low-Low.
    e) Signal fail.
    f) Other.
12) PLC NO: PLC number.
13) PLC I/O: PLC I/O address.
14) PLC Registers Number: The PLC resister that the SCADA reads or writes to.

c. SCADA Database: The PIC Integrator shall provide a database of all SCADA database points that are not included in the analog or discrete I/O Databases in that are communicated to and from the SCADA. The database shall be configured in a Microsoft EXCEL or ACCESS database. SCADA database includes the following fields:
    1) Loop number.
    2) CITECT VIEJO block tag number.
    3) CITECT VIEJO block type.
    4) CITECT VIEJO SCADA node the point is assigned to.
    5) Point description.
    6) Alarm Description 1.
    7) Alarm Description 2.
    8) Engineering units.
    9) Scale range.
    10) Alarms functions to be configured in CITECT VIEJO block configuration:
        a) High-High.
        b) High.
        c) Low.

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d) Low-Low.
e) Signal fail.
f) Other.

2.04 STANDARD PLC/SCADA FUNCTIONS BLOCKS

A. General: The follow Standard functions blocks specify the standard PLC/SCADA functions block to be developed and used to implement the PLC/SCADA requirements specified in the Loop Specifications.

B. Discrete SCADA/PLC Mode Command and Feed Back Status: When the SCADA commands the PLC to specific mode such as Auto or Manual, the SCADA shall be configured with an Auto write command database point and an in Auto mode database status.

C. Analog SCADA/PLC Read-Write Process: When an analog value such as setpoint or controller output is specified to be accessible to the operator, the SCADA shall be configured to write to the PLC register through one database tag and then read back the variable written to the PLC through a second database tag.

D. Discrete Alarm Inputs: Provide second delay timer on alarm inputs to mitigate false alarm conditions.

E. Discrete Equipment Control:

1. Controlled equipment to have LOCAL-OFF REMOTE switch with REMOTE/NOT REMOTE input to the PLC. The Controlled equipment shall include RUNNING status. PLC outputs include a START/STOP (or separate START and STOP signals) to operate the equipment. The Applications Software shall prevent Start/Stop control of equipment by the PLC unless the LOR switch is in the REMOTE position.
2. When the controlled Equipment is in COMPUTER the SCADA and PLC shall be enabled to set the Equipment mode to SCADA COMPUTER or SCADA MANUAL. When the controlled Equipment is in SCADA Manual the SCADA and PLC shall be configured to Start and Stop the Equipment from the SCADA. When the Controlled Equipment is in SCADA REMOTE the automatic PLC routine shall control the RUNNING status of the Equipment.
3. Monitor the RUNNING status of equipment in the COMPUTER mode. If the PLC calls for the equipment to START and does not receive an RUNNING signal after a suitable time delay, lock out the equipment in the PLC and generate an alarm to the SCADA.
4. If the equipment is not in REMOTE mode the logic shall set the mode Manual.

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5. Equipment Available Statues: Provide equipment available status that is logically true when equipment is in REMOTE, SCADA AUTO and not FAILED.
6. If the PLC calls for the equipment not to STOP and the RUNNING signal is true after a suitable time delay, lock out the equipment in the PLC and generate equipment failure alarm to the SCADA.
7. The equipment failure alarm condition and the equipment lock out shall be cleared by the loss of the AUTO signal or SCADA initiated Reset.
8. Provide a test input that to be used for system testing. When the TEST input is true the START/STOP output shall be prohibited from energizing. When in this mode, the RUNNING status points read by the SCADA and used by the PLC logic will follow the command to run, instead of the field RUNNING inputs.
9. Provide a bumpless transfer between SCADA-MANUAL and SCADA-AUTO or SCADA-AUTO to SCADA-MANUAL mode. If the equipment is running it shall continue running when transferred to SCADA-MANUAL or SCADA-AUTO.

F. Lead/Standby and Sequence Pump Control:

1. The lead/standby provides control over two redundant pumps.
2. The lead pump can run continuously or when called to run.
3. The lag pump runs when the lead pump is not available or is not RUNNING.
4. Provide a FAIL output that goes true if there is no sequence selected or no pumps are available.
5. Provide a 1-2 and 2-1 lead/lag sequence selection from the SCADA.
6. Provide hysteresis timers to prevent equipment from dropping and out of operation when process variable is sitting adjacent to mode setpoint.

G. Discrete Valve (or Gate) Control:

1. Controlled valves have LOCAL OFF REMOTE and OPEN-CLOSED switches with OPENED, CLOSED and REMOTE inputs to the PLC. PLC outputs include an OPEN signal (or separate OPEN and CLOSE signals) to open the valve. The applications software shall prevent control of valve by the PLC unless the LOCAL OFF REMOTE switch is in the REMOTE position.
2. Equipment Available Statues: Provide equipment available status that is logically true when equipment is in REMOTE, SCADA AUTO and not FAILED.
3. When the controlled valve is in REMOTE the SCADA and PLC shall be configured to set the valve mode to SCADA AUTO or SCADA MANUAL. When the controlled valve is in SCADA Manual the SCADA and PLC shall be configured to Open and Close the valve from the SCADA. When the Controlled valve is in SCADA AUTO the

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automatic PLC routine shall control the Open/Close position of the valve.

4. Monitor the OPENED/CLOSED status of valve in the AUTO position. If the SCADA/PLC calls for the valve to OPEN and does not receive an OPENED signal after a suitable time delay, lock out the valve in the PLC and generate an alarm to the SCADA.
5. If the PLC calls for the valve to CLOSE and continues to receive an OPENED signal or does not receive a CLOSED signal after a suitable time delay. Generate a valve failed alarm to the SCADA.
6. The alarm condition and the valve shall be cleared when the valve is noted to be in the correct position.

H. Analog Inputs:

1. Provide sample times for analog inputs of no slower than one sample every 2 seconds. For inputs that are used for control purposes, use sample times no slower than once every 1 second.
2. Provide a first order digital filter on all analog inputs. Use the PLCs built-in lag filter and set the time constants to no greater than four times the input sample time.
3. All analog inputs shall be configured into a floating point variable and scaled in engineering units.
4. Provide analog switches on each analog input. Analog switches to provide High and Low alarms, or as shown or as described in the loop specifications. The setpoints for the analog switches shall be accessible and changeable through the SCADA.
5. Monitor signal failure (out of normal range) on all analog inputs and alarm on the SCADA.

I. Analog Switches:

1. All analog switches used for Process alarms, to START and STOP pumps, sequences, etc. shall be configured through analog switches. Two types of analog switches shall be provided one for rising signal and one for falling signal. Each analog switch shall be configured with a 1 percent dead band to prevent nuisance tripping. Provide operator access through the SCADA to the analog switch setpoints.
2. Each analog alarm shall be configured with four inputs and one output.
   a. Inputs:
      1) Process variable scaled in engineering units.
      2) Setpoint.
      3) Minimum and Maximum engineering units.
   b. Outputs: Discrete output that switches when the process variable is above or below the setpoint.

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J. Analog Control:

1. Unless otherwise noted, controllers shall be configured as Proportional-Integral (PI) type. Unless specifically noted do not use derivative mode.
2. Provide access through the SCADA for discrete mode changes, Setpoint and controller output when the controller is in manual.
3. Controller gain and integral time constant shall be adjusted to provide stable operation normal operating conditions.
4. Use the position from of the PI equation unless otherwise noted.
5. Freeze the controller bias to prevent reset wind up, if the output is out of range.
6. Controller sample times shall be no slower than once every 2 seconds.
7. Provide bumpless transfer between operating modes, Auto to manual, and manual to auto.
8. Provide a SCADA Controller tuning display for each loop. The tuning display shall have a trend that trends the Process Variable, Setpoint and Output.
9. Provide a setpoint initialization routine that initializes the setpoint to the value of process variable when the loop in set to Automatic.
10. Unless otherwise noted, the Analog control shall be one shot into Manual when signal failure is detected on the Process variable. Provide a SCADA alarm that indicates that the loop was set to MANUAL.

K. Alarm Processing:

1. Provide alarms as noted or shown.
2. All alarms shall be configured into Alarm Areas as specified by the Owner in the Workshops.
3. Discrete type alarms shall be provided with an adjustable delay timer so that they do not become nuisance alarms.

L. Manual Equipment Control from the PLC:

1. Provide a SCADA AUTO/MANUAL mode for PLC-controlled devices. In the SCADA AUTO mode, the device shall operate as described in the Loop Specifications. In the SCADA MANUAL mode, the operator shall control the device through Start/Stop or Open/Close commands from the SCADA.
2. The software AUTO/MANUAL selection shall be allowed only when the device’s panel switch is in the AUTO position.
3. Provide MANUAL mode start and stop capability on all equipment, valves, and packaged systems (devices) that are controlled from the PLC, unless otherwise noted.
4. Receive a discrete variable from the SCADA in the MANUAL mode, indicating that the device should start or stop (open or close).

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5. When the device is in MANUAL, disable normal sequence of operations from controlling the device. Do not override shut-down interlocks.

M. Run-Time Counters:

1. Provide a run-time counter for all motorized equipment that has a RUNNING signal to the PLC.
2. Accumulate run times in hours with a minimum resolution of 0.1 hour. Counters shall roll over automatically when the accumulator is full.
3. Provide for a contact from the SCADA to reset all run-time counters, on demand or by reaching a preset of 30,000 hours
4. Store all run-time counters in a linear block of PLC memory for transmission to the SCADA.

N. Sequences:

1. Sequences specified in the loop descriptions shall have the following general requirements:
   a. All sequences shall be divided into individual steps and be a command Functional Test -back type sequence. For example, the PLC shall issue a command for a valve to open (or pump to start) and will monitor the valve limit switches (or motor starter auxiliary contact or flow switch) to verify that it did open (or pump start). If the correct feedback status is not received within a preset time limit an individual failed alarm shall be initiated.
   b. Once a sequence has been started, it shall advance from one step to the next when all of the previous steps commanded by the PLC have been verified by the “report-back” portion of the program.
   c. Each sequence shall have a systems level MANUAL/OFF/AUTOMATIC control from the SCADA. In the OFF mode the sequence shall be reset to the home, step 0. In the manual mode the sequence shall be started by a SCADA START/STOP control. In the AUTOMATIC mode the sequence shall be started by the specified automatic control functions.
   d. If in any sequence step, a device fails to respond to the control of the PLC the sequence shall stop and remain in the current step. The sequence shall remain in the failed step until the SCADA start function is initiated. The sequence will then retest the current step and advance to the next step if the device has responded to the control action.

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e. Each sequence shall have a SCADA JOG function. The JOG function shall advance the step by one, independent of the normal step advance conditionals and timers.
f. Each sequence shall transmit bit variable indicating the active step to the SCADA.

O. Totalization: All Flow and Power signals shall be totalized in the PLC and communicated to SCADA. Total shall be computed based upon either PULSE TOTAL discrete inputs from the field device or by integrating the process variable with the PLC scan and execution time. PLC special function programs shall be configured to scale the process variable to be totalized into MGD or KWH. Accumulated Totals shall be manually reset by the Operator.

PART 3 EXECUTION

3.01 TESTING

A. General:

1. Test software to demonstrate that the applications software satisfies requirements outlined in the Loop specifications, and described in submittals, and workshops.
2. Test Format: Cause and Effect:
   a. Person conducting test initiates input (cause).
   b. Specific test requirement is satisfied if correct result (effect), occurs.
3. Procedures, Forms, and Checklists:
   a. The Test will be completed on a unit operation and loop basis that is design to coordinate with the PIC testing and startup.
   b. The PIC Integrator shall generate testing forms, and checklists from the SCADA/PLC database.
   c. Have space after each test item description for sign off by appropriate party after satisfactory completion.

B. Staging Site Demonstration Test (SSDT):

1. Scope: Test entire PLC and SCADA to demonstrate that hardware (PLC, HMI, Communications) and application software are operational. The SSDT shall be successfully completed to the satisfaction of the Engineer before the software is loaded on to the Plant SCADA and PLC.
2. Location: PIC Integrator’s facility.
3. SCADA Display Tests: The Object of the test is to verify all SCADA database points and points communicated between the SCADA and PLC and not the operation of the PLC software. Each SCADA display and dynamic object on that display and control will be tested and verified. The Applications PIC Integrator shall provide a test form for

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each display that lists all of dynamic objects, controls, pop-up windows and their associated database tags and corresponding PLC address. The test form shall provide a place for a sign off for the PIC Integrator Owner and Engineer.

4. SCADA Display Navigation Test: The Objective of the test is to verify all the display navigation controls.
5. Loop-Specific Functions: Demonstrate functions shown on P&IDs, specified in the Loop Specifications, described in submittals, and workshops. This test shall not be started until the Display and Display navigation tests have been successfully completed. This test shall verify all SCADA and PLC functions through indications on the SCADA and the PLC programming software. The Applications PIC Integrator shall develop a test form on and unit Operation and loop basis. The form shall list all controlled equipment, control routines, alarm points, status points, setpoints, controllers, sequences that are specified in the Loop Specifications. The test shall demonstrate all manual and automatic functions are operating as specified and verify that the outputs and inputs are configured to the correct PLC I/O point.
6. Make following documentation available to Owner at Test Site both before and during SSDT:
    a. Loop specifications.
    b. Pre-software design submittal.
    c. Software design submittal.
    d. O&M material.
    e. Master copy of SSDT sign off sheets.
    f. Applications software documentation.

C. Functional Test Part 1: Prior to Phase 2 Functional Test, startup test period and PAT for the purpose of inspecting, testing, and documenting that entire PIC is ready for automated operation. Test and document that process equipment, panels, instruments, wiring, cables, and etc., excluding PIC Integrator provided applications software (PLC and HMI).

D. Functional Test Part 2 Functional Tests:

1. Phase 2 Functional Test: Combined effort between Contractor and PIC Integrator to confirm that PIC and applications software are ready for operation.
    a. Prerequisite: Completion of Phase 1 Functional Test.
    b. Joint test with PIC Integrator. Repeat of PIC Integrator's SSDT, except using real field sensors and equipment. Plant interlocking and communications with PLCs and SCADA shall be tested on loop-by-loop basis.
    c. Test procedures provided by PIC Integrator based on Loop Specifications.

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E. Performance Acceptance Tests (PAT): These are the activities that Section 01 91 14, Equipment Testing and Facility Startup, refers to as performance testing.

1. Once Functional Test Phase 1 and Phase 2 has been completed and facility has been started up, perform a witnessed PAT on complete PIC and software to demonstrate that it is operating as required by the Contract Documents and software loop descriptions. Demonstrate each required function on a paragraph-by-paragraph, loop-by-loop basis.
2. Loop-specific and non-loop-specific tests same as required for SSDT except that entire installed PIC tested using actual process variables and all functions demonstrated.
3. Perform local and manual tests for each loop before proceeding to AUTO and automatic modes.
4. Where possible, verify test results using visual confirmation of process equipment and actual process variable. Unless otherwise directed, exercise and observe devices supplied by others, as needed to verify correct signals to and from such devices and to confirm overall system functionality. Test verification by means of disconnecting wires or measuring signal levels is acceptable only where direct operation of plant equipment is not possible.
5. Make updated versions of documentation required for PAT available to Owner at Site, both before and during tests.
6. Make one copy of all software O&M manuals available to the Owner at the Site both before and during testing.

3.02 OWNER TRAINING

A. General: See Section 01 79 20 for more detail.

3.03 O&M MANUALS

A. General: Provide the following:

1. In accordance with Section 01 78 23, Operation and Maintenance Data.

B. Software: Provide the following:

1. Documented ladder programs.
2. PLC/SCADA I/O database, forms, queries, and reports.

END OF SECTION

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SECTION 40 97 00
PROCESS CONTROL NARRATIVES (PCN)

Cutter Lateral Water Treatment Plant

Overview

Preliminarily, we foresee the flow management through the CLWTP governed by maintenance of an operator selected water surface elevation in Regulating Tank No. 3 downstream of the CLWTP. Thus, the finished water pump station will automatically operate to maintain such level. Upstream, the raw water flow control valves will modulate to maintain a raw water flow rate equal to the finished water flow rate less potential recycle flow contribution. Each of the previous flow streams (finished water, raw water to each pretreatment basin, recycle) will be equipped with a magmeter.

Within the plant itself, the raw water flow, control valves will also automatically split the raw water flow amongst the pretreatment trains selected for operation. The flow split amongst the filters will be accomplished automatically with filter effluent flow control valves and magmeters dedicated to each filter. The filter effluent will then combine and flow to the clearwell.

The filter effluent header will have a turn out to the granular activated carbon (GAC) absorber influent pump station wet well. The GAC absorber influent pump station flow, set point, and the pumps will operate for less than 1 MGD Plant Influent Flow, then flow will be switched to the Plant Filters.

With respect to filter backwash wastewater flow management, there will be a permissive water level in the off-spec and backwash wastewater ponds, so if there is insufficient volume to receive a backwash volume, the backwash initiation will be blocked until sufficient volume is present. This is not anticipated to be a bottleneck, as the liquid residuals ponds include sufficient volume to accommodate four consecutive backwashes. The filters will readily provide 24-hour filter runs, significantly reducing the likelihood of needing four consecutive backwashes.

The clarification sludge will gravity flow to the solids pump station based on operator selection of sludge collector frequency and duration of operation. The solids pump station will convey both the clarifier and backwash waste pond solid residuals to the solids drying beds.

The decant from the sludge drying beds and the backwash wastewater equalization and settling ponds will normally be sent to a National Pollutant Discharge Elimination System (NDPES) discharge point in the arroyo running east to west just north of the plant site. The decant pump station also has capability and capacity to alternatively recycle up to 10 percent of the plant flow to upstream of the pretreatment basins.

Most of the water holding basins in the plant can gravity drain to the off spec and backwash waste ponds to facilitate maintenance. Complete dewatering of the clearwell is accomplished with a separate dewatering submersible pump system(s).

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List of Sections

1. Flocculation and Sedimentation
2. Filters and GAC
3. Finished Water Pump Station
4. Chemical Facility
5. Off Spec/Backwash Pond
6. Decant Pump Station

Plant SCADA

Plant SCADA will incorporate Vijeo Citec HMI and Schneider Electric Modicon (M340) PLCs Architectures. Plant HMI and PLC are to be programmed to provide automated control and monitoring of liquid and solids systems.

Standard Programming Functions

Operating Modes:

The facility will be designed with four levels of control, as follows:

- *Local Control:* Equipment will have a method of local manual control for situations when the PLC or the operator workstations are not available. ON-OFF-REMOTE selector switches will be provided to transfer control to/from the PLC. In the ON mode, PLC control will be bypassed, and the equipment can be operated from the MCC. Hardwired interlocks for personnel safety and equipment protection, such as E-STOP, motor overloads, and equipment protection, etc., are independent of the control mode.
- *Local Manual and Automatic Control:* Various package control systems will automatically adjust/operate equipment to maintain normal process conditions. Operator control is implemented through Package Control System OITs. OITs will provide operators with the ability to control, monitor, and alarm Package Control System.
- *Remote – SCADA Manual Control:* This mode will allow equipment to be manually operated from the operator workstations, industrial workstations, or OITs through the PLC system. SCADA Manual control will be independent of process conditions (level, flow, temperature, etc.).
- *Remote – SCADA Automatic Control:* The PLC system will automatically adjust/operate equipment to maintain normal process conditions. SCADA Automatic control is implemented through any workstation. Workstations will provide operators with the ability to control, monitor, and trend any process in the WWTP.

Standard PLC and HMI Programming Functions:

- Program network communications and transfer of data between PLCs, HMI, and OITs.
- Program PLANT SCADA HMI such that equipment NOT IN REMOTE cannot be operated at Plant SCADA. HMI. Equipment pop-up (grayed back) on HMI displays.

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- Program equipment FAULTs to start and FAULT to stop alarms.
- Program valve FAULT to open and valve FAULT to close alarms.
- Program equipment operations for multi-pump (equipment) applications as defined below. Equipment out of service FAULT OR NOT IN REMOTE shall be removed from sequence. *Note: Duplex operations 100 percent redundant pump (equipment) shall be designated as lead-standby.*
  - LEAD-STANDBY or DUTY-STANDBY (if we are only allowing 1 pump to operate and the other is truly a backup).
  - LEAD-LAG (if we are allowing two pumps to operate together).
  - LEAD-LAG-STANDBY (if we are allowing two pumps to operate together and the third pump is truly a backup).
  - LEAD-LAG1-LAG2 (if we are allowing three pumps to operate together).
  - LEAD-LAG1-LAG2-STANDBY (if we are allowing three pumps to operate together and the fourth is truly a backup).
  - LEAD-LAG1-LAG2-LAG3 (if we are allowing four pumps to operate together).
  - Some pump application are none of the above since they are manually valved and dedicated to one process apparatus.
- Program equipment such that in the event of LEAD FAULT condition, the STANDBY, LAG, or LAG1 pump operates as LEAD. In the event of LAG or LAG1 FAULT condition, the STANDBY or LAG2 pump operates as LAG or LAG1.
- Program equipment stagger start after power FAULT and return to standby generator or normal power operations.
- Remove start, open, and close commands to FAULTED and OUT-OF-SERVICE equipment.
- Monitor, scale, data log, display, and trend process variables that are measured including: level, flow rates, pressure, temperature, turbidity, total and free chlorine residuals, speed, motor current, and process streaming current.
- Program process totals, including: flow (volume totals instantaneous and daily), equipment run times, and equipment number of starts.
- Program instrument OUT-OF-RANGE and UNDER-RANGE monitoring and alarming.
- Monitor and display at Plant HMI equipment status, controls, alarms, and trends.
- Operate equipment in SCADA AUTO and SCADA MANUAL control from Plant HMI (OPEN-CLOSE, RUN , adjust position, speed, flow rates, level, residual mode, cascade mode, trim, etc.).

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- Adjust process and alarm set-points from Plant HMI (LOW, LOW-LOW, HIGH, HIGH-HIGH, FLOW, LEVEL, RATIO, RESIDUAL, PRESSURE, POSITION, SPEED, DOSE, TIME, DURATION, and INTERVAL).
- Acknowledged alarms shall revert back to an active alarm condition in the event the alarm condition is not cleared after an adjustable period of time.
- In the event of a PLC communication FAULT, ALARM and maintain last operating condition.
- Process Alarms are latched by PLC(S) control logic and RESET by selecting between REMOTE or AUTO to OFF mode at local control station.
- Program PLC to generate PROCESS NO FLOW alarm when pump is operating (RUNNING) and flow is not measured by associated flow meter or flow switch after an adjustable period of time.
- **Program ADD-ON Functionality per CH2M Standards.**

Non-Standard Programming Functions:

Dosage Control:

Plant SCADA generates calculated flow set-points in gallons per minute, gallon per hour, or liters per hour:

Pump Flow Set-point (GPM) = (D x Q)/ (AF x C x SG)

Where:

D = dose (mg/L); operator entered as described above

Q = Flow-Paced Flow Rate (GPM or MGD) instruments to be noted per the specific process

C = Concentration (percentage is entered as a value, e.g., 6 percent would be entered as 0.06 in the above formula)

SG = Specific Gravity; operator-entered value based upon actual delivered chemical system properties.

AF = Adjustment Factor (1440 initially). This value is entered by Operator at Plant SCADA based upon D, Q, and Flow Set-point (GPM, GPH, Lbs. /day, or LPH).

Chemical Application Control (lbs. /day):

Chemical application rate, (lbs. /day) = [(D Chemical dosage, mg/L) x (Q Flow, MGD) x 8.34]/(C x SG)

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Where:

D = dosage mg/L operator entered as described above

Q = Flow-Paced Flow Rate (GPM or MGD) instruments to be noted per the specific process.

C = Concentration (mg/L)

SG = Specific Gravity; operator-entered value based upon actual delivered chemical system properties.

Convert Feed Rate to match Chemical Pump Capacity

Calibration:

Chemical Feeder (lbs. /day) = (Chem Conc. mg/L) x (Vol pumped, mL) (1,440 min/day)/ [(Time pumped, min) x (1,000 mL/L) x (1,000 mg/g) x (454 g/lb.)]

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Section – Flocculation and Sedimentation

Process Unit/Facility is Flocculation Sedimentation. RW Facility number is 280.

Process Overview

Raw water (RW) enters the plant via a 24-inch pipeline from regulating Tank No. 2. Plant Influent Flow Set-point will be determined by the Finished Water Flow Rate to Tank 3 minus the Recycled flow from the Decant station. Flow is split between Rapid Mix Basin 1 and 2 by way of Flow Control Valves and Flowmeters in each basin Inlet line.

Rapid Mix Basin 1 and 2 each have two VFD driven mixers. Speed is set by the operator form SCADA. Turbidity is sampled at the common inlet line to Rapid Mix and displayed at SCADA.

Sulfuric Acid and Ferric Chloride are dosed at each Rapid Mix Basin based on flow into each basin.

Water Flows from each Rapid Mix Basin into the Flocculation Influent channel. The Channel is divided by a crossover gate, normally closed. Flocculation Basins are fed from the influent channel through an influent channel gate for Flocculation Basin 1 and an influent gate for Flocculation Basin 2. Influent gates can be opened or closed to take a Flocculation basin off line.

Anionic Polymer is added to each Flocculation basin to aid in flocculation.

Each Flocculation basin has 3 pairs of Flocculation mixers. Each pair is driven by a common VFD.

Sludge is collected from each Flocculation Basin and transferred to the Sludge Transfer Station by two vendor supplied sludge collector packages. Sludge is transferred to the Sludge Transfer Station where it is pumped to the Solids Drying Ponds.

Ph is measured at the Influent and Effluent of each Flocculation Basin. Turbidity is also measured at the Effluent of each basin.

References

Drawing	Description
008-I-0001	Rapid Mix Sulfuric Acid and ferric Chloride P&ID
008-I-0002	Flocculation and Sedimentation Basin 1 P&ID
008-I-0003	Flocculation and Sedimentation Basin 2 P&ID

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Equipment

Equipment	Description	Drawing
MXR28010103	Basin 1 Rapid Mixer 1	008-I-0001
MXR28010104	Basin 1 Rapid Mixer 2	008-I-0001
MXR28010403	Basin 2 Rapid Mixer 1	008-I-0001
MXR28010404	Basin 2 Rapid Mixer 2	008-I-0001
FCV28010102	Rapid Mix 1 Flow Control Valve	008-I-0001
FCV28020102	Rapid Mix 2 Flow Control Valve	008-I-0001
PMP28010002	Raw Water Sample Pump	008-I-0001
MXR28010401A	Basin 1 Flocc Mixer 1	008-I-0002
MXR28010401B	Basin 1 Flocc Mixer 2	008-I-0002
MXR28010402A	Basin 1 Flocc Mixer 3	008-I-0002
MXR28010402B	Basin 1 Flocc Mixer 4	008-I-0002
MXR28010403A	Basin 1 Flocc Mixer 5	008-I-0002
MXR28010403B	Basin 1 Flocc Mixer 6	008-I-0002
PMP28010603	Sedimentation Effluent Sample Pump	008-I-0002
GTE28010302	Flocc Basin Influent Gate	008-I-0002
SLC28010501	Basin 1 Sludge Collector	008-I-0002
MXR28020401A	Basin 2 Flocc Mixer 1	008-I-0003
MXR28020401B	Basin 2 Flocc Mixer 2	008-I-0003
MXR28020402A	Basin 2 Flocc Mixer 3	008-I-0003
MXR28020402B	Basin 2 Flocc Mixer 4	008-I-0003
MXR28020403A	Basin 2 Flocc Mixer 5	008-I-0003
MXR28020403B	Basin 2 Flocc Mixer 6	008-I-0003
PMP28020603	Sedimentation Effluent Sample Pump #2	008-I-0003
GTE28020302	Flocc Basin 2 Influent Gate	008-I-0003
GTE28030000	Flocc Basin 1 to 2 Cross Connect Gate	008-I-0003

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Equipment	Description	Drawing
SLC28020501	Basin 2 Sludge Collector	008-I-0003

Instrument

Instrument	Description	Drawing
AIT28010001	Raw Water Turbidity	008-I-0001
FIT28010101	Train 1 Rapid Mix Flow	008-I-0001
FIT28020101	Train 2 Rapid Mix Flow	008-I-0001
AIT28010301	Flocc basin 1 Influent Ph	008-I-0002
AIT28010601	Flocc basin 1 Effluent Ph	008-I-0002
AIT28010602	Flocc basin 1 Effluent Turbidity	008-I-0002
LIT28010404	Flocc basin 1 Level	008-I-0002
AIT28020301	Flocc basin 2 Influent Ph	008-I-0003
AIT28020601	Flocc basin 2 Effluent Ph	008-I-0003
AIT28020602	Flocc basin 2 Effluent Turbidity	008-I-0003
LIT28020404	Flocc basin 2 Level	008-I-0003

System Description and Operation

Rapid Mix Basins and Mixers

Flow is split between Rapid Mix Basin 1 and 2 by way of Flow Control Valves and Flowmeters in each basin Inlet line. FCV28010102 and FIT28010101 for Basin 1 and FCV28020102 & FIT28020101 for Basin 2. The Overall Plant Flow Set-point is determined by Flow rate to Finishing Water Storage Tank 3 (FIT36030401) minus the Flow to the head of the plant form the Decant station. The Set-point will be split between the Online Rapid Mix Basins.

Rapid Mix Basin 1 and 2 each have two VFD driven mixers:

MXR28010103 and MXR28010104 for Rapid Mix Basin 1 and MXR28020103 and MXR28020104 for Rapid Mix Basin 2. Speed for each mixer is set by the operator from SCADA. The Turbidity is sampled at the common inlet line to Rapid Mix and displayed at SCADA.

Sulfuric Acid and Ferric Chloride are dosed at each Rapid Mix Basin based on flow into each basin.

Flocculation Basins and Mixers

Water Flows from each Rapid Mix Basin into the Flocculation Influent channel The Channel is divided by a crossover gate GTE28030000. Each Flocculation Basin is fed from the

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influent channel through an influent channel gate GTE28010302 for Flocculation Basin 1 and GTE28020302 for Flocculation Basin 2. The gates can be opened or closed to take a Flocculation basin off line.

Anionic Polymer is added to each Flocculation basin from Anionic Polymer Pumps 3 thru 6 to aid in flocculation.

Each Flocculation basin has three pairs of Flocculation mixers.

MXR28010401A and MXR28010401B

MXR28010402A and MXR28010402B

MXR28010403A and MXR28010403B

Each pair is driven by a common VFD. Speed is set manually by the operator from SCADA with the first mixer in line running the fastest and each succeeding Mixer running at a progressively lower speed.

Minimum Flocculation basin level for running the mixers is: [TBD] feet as measured by LIT-28010404 in Basin 1 and LIT28020404 in Basin 2.

Flocculation Sludge Collectors

Sludge is collected from each Flocculation Basin and transferred to the Sludge Transfer Station by a vendor supplied sludge collector package. SLC28010501 in Basin 1 and SLC28020501 in Basin 2. Each Sludge Collector Control Panel is connected to the plant network over Ethernet. In Auto, the Sludge Collectors will be enabled from SCADA based on the level in the Sludge Transfer Station as measured by LIT44044001. Max level for running the Sludge Collectors is [TBD] feet.

Ph is measured at the Influent and Effluent of each Flocculation Basin. Turbidity is also measured at the Effluent of each basin.

Automatic Control

Rapid Mixers – MXR28010103, MXR28010104 and MXR28020103, MXR28020104

- Program REMOTE SCADA-AUTO/MANUAL RUN control at Plant SCADA.
- Program ON-OFF-REMOTE status at Plant SCADA.
- Program Duty/ Standby at Plant SCADA.
- Program ALARM status at Plant SCADA.
- Program STANDARD FUNCTIONS as defined by Project Applications Software Standards.

Flocculation Mixers – MXR28010401, MXR2801042 and MXR28010403

- Program REMOTE SCADA-AUTO/MANUAL RUN control at Plant SCADA.
- Program ON-OFF-REMOTE status at Plant SCADA.
- Program Duty/ Standby at Plant SCADA.

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- Program ALARM status at Plant SCADA.
- Program STANDARD FUNCTIONS as defined by Project Applications Software Standards.

Rapid Mix Influent Valves – FCV280X0101- (X=1, 2)

- Program REMOTE SCADA-AUTO/MANUAL control at Plant SCADA.
- Program LOCAL-REMOTE status at Plant SCADA.
- Program FLOW CONTROL set-points at Plant SCADA.
- Program ALARM status at Plant SCADA.
- Program STANDARD FUNCTIONS as defined by Project Applications Software Standards.

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Section – Filtration and GAC

Process Unit/Facility is Process Filters FI, FE, FTW BWS, and BWW. Facility number is 300.

Process Overview

Clarified water from the Flocculation Basins flows into the Filter Influent channel where it is distributed among the online filters. Each filter has an Inlet Isolation Valve, Effluent Flow Control Valve and Flow Meter, Filter To Waste Valve, Backwash Supply Valve and Air Scour Valve. Filter Level, Differential Pressure, and Turbidity are measured for each filter.

Individual Filter Flow set-point is determined as follows: Influent Flow is measured at each Flocculation Basin inlet, the total Flow is divided evenly among the online filters. The individual Filter FCV and FIT are used to achieve the required flow set-point for the filter.

Filtered water flows from each Individual Filter through the Filter Seal Weir and through the GAC (Granulated Activate Carbon) tanks for further filtering.

The operator will select the GAC absorber influent pump station flow, set point, and the pumps will operate to deliver this flow (variable from about 0.25 to 1 mgd) to the GAC absorber. The GAC absorber effluent will then recombine with the balance of the filter effluent and flow to the clearwell.

Back wash of the filters can be performed manually, or initiated automatically according to Turbidity, D/P, or time since last backwash.

Backwash Supply water is taken from the Finished Water Wet Well and supplied to each filter as needed during a backwash. Air Scour is supplied by the air scour blower and modulating valve.

References

Drawing	Description
008-I-0004	Filter Overview P&ID
008-I-0005	Filter 1 P&ID
008-I-0006	Filter 2 P&ID
008-I-0007	Filter 3 P&ID
008-I-0008	Filter 4 P&ID
008-I-0009	Filter Air Scour P&ID

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Drawing	Description
008-I-0010	Filter Seal Water P&ID
008-I-0011	GAC Supply Pumps P&ID
008-I-0012	GAC Adsorber P&ID

Equipment

Equipment	Description	Drawing
FV30010101	Filter 1 Influent Valve	080-I-0005
FV30010102	Filter 1 BWW Valve	009-I-0005
FV30010103	Filter 1 BWS Valve	009-I-0005
FV30010104	Filter 1 Air Scour Valve	009-I-0005
FCV30010105	Filter 1 Effluent Control Valve	009-I-0005
FV30010106	Filter 1 Effluent Isolation Valve	009-I-0005
FV30010107	Filter 1 FTW Valve	009-I-0005
FV30020101	Filter 2 Influent Valve	080-I-0006
FV30020102	Filter 2 BWW Valve	009-I-0006
FV30020103	Filter 2 BWS Valve	009-I-0006
FV30020104	Filter 2 Air Scour Valve	009-I-0006
FCV30020105	Filter 2 Effluent Control Valve	009-I-0006
FV30020106	Filter 2 Effluent Isolation Valve	009-I-0006
FV30020107	Filter 2 FTW Valve	009-I-0006
FV30030101	Filter 3 Influent Valve	080-I-0007
FV30030102	Filter 3 BWW Valve	009-I-0007
FV30030103	Filter 3 BWS Valve	009-I-0007
FV30030104	Filter 3 Air Scour Valve	009-I-0007
FCV30030105	Filter 3 Effluent Control Valve	009-I-0007
FV30030106	Filter 3 Effluent Isolation Valve	009-I-0007
FV30030107	Filter 3 FTW Valve	009-I-0007
FV30040101	Filter 4 Influent Valve	080-I-0008

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Equipment	Description	Drawing
FV30040102	Filter 4 BWW Valve	009-I-0008
FV30040103	Filter 4 BWS Valve	009-I-0008
FV30040104	Filter 4 Air Scour Valve	009-I-0008
FCV30040105	Filter 4 Effluent Control Valve	009-I-0008
FV30040106	Filter 4 Effluent Isolation Valve	009-I-0008
FV30040107	Filter 4 FTW Valve	009-I-0008
BLW30000102	Air Scour Blower 1	009-I-0009
BLW30000102	Air Scour Blower 1	009-I-0009
FCV30000301	Air Scour Blowers Control Valve	009-I-0009
PMP30010101	GAC Influent Sample Pump 1	009-I-0010
PMP30010102	GAC Influent Sample Pump 2	009-I-0010
PMP30030101	Chemical Injection Sample Pump	009-I-0010
PMP30010501	GAC Supply Pump 1	009-I-0011
PMP30010502	GAC Supply Pump 2	009-I-0011
PMP30010503	GAC Supply Pump 3	009-I-0011
FV30010604	GAC Adsorber Vessel 1 to BWW Valve	009-I-0012
FV30010504	GAC Adsorber Vessel 2 to BWW Valve	009-I-0012
FV30010601	GAC Pumps to Adsorber Vessel 2 Valve	009-I-0012
FV30010501	GAC Pumps to Adsorber Vessel 1 Valve	009-I-0012
FV30010605	Adsorber Vessel 1 to Vessel 2 Valve	009-I-0012
FV30010505	Adsorber Vessel 2 to Vessel 1 Valve	009-I-0012
FV30010502	GAC Water to Filter Effluent Valve 1	009-I-0012
FV30010602	GAC Water to Filter Effluent Valve 2	009-I-0012
FV30010700	BWS to GAC VLV	009-I-0012
TNK30010500	GAC Adsorber Vessel 1	009-I-0012
TNK30010600	GAC Adsorber Vessel 2	009-I-0012
TNK30010601	Carbon Acceptance Vessel	009-I-0012

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Instrument

Instrument	Description	Drawing
LIT30010101	Filter 1 Level	009-I-0005
PDIT30010101	Filter 1 Differential Pressure	009-I-0005
AIT30010101	Filter 1 Effluent Turbidity	009-I-0005
FIT30010101	Filter 1 Effluent Flow	009-I-0005
LIT30020101	Filter 2 Level	009-I-0006
PDIT30020101	Filter 2 Differential Pressure	009-I-0006
AIT30020101	Filter 2 Effluent Turbidity	009-I-0006
FIT30020101	Filter 2 Effluent Flow	009-I-0006
LIT30030101	Filter 3 Level	009-I-0007
PDIT30030101	Filter 3 Differential Pressure	009-I-0007
AIT30030101	Filter 3 Effluent Turbidity	009-I-0007
FIT30030101	Filter 3 Effluent Flow	009-I-0007
LIT30040101	Filter 4 Level	009-I-0008
PDIT30040101	Filter 4 Differential Pressure	009-I-0008
AIT30040101	Filter 4 Effluent Turbidity	009-I-0008
FIT30040101	Filter 4 Effluent Flow	009-I-0008
PDSH30000102	Air Scour Blower 1 Inlet Filter DP	009-I-0009
TSH30000102	Air Scour Blower 1 Discharge Hi Temp	009-I-0009
PDSH30000202	Air Scour Blower 2 Inlet Filter DP	009-I-0009
TSH30000202	Air Scour Blower 2 Discharge Hi Temp	009-I-0009
FIT30000302	Filter Air Scour Air Flow	009-I-0009
FIT30010001	Filter Seal Water Flow To GAC	009-I-0011
PIT30010504	GAC Supply Pump Combined Discharge Pressure	009-I-0011
DPS30010500	GAC Adsorber Vessel 1 Differential Pressure Switch	009-I-0012

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Instrument	Description	Drawing
DPS30010600	GAC Adsorber Vessel 2 Differential Pressure Switch	009-I-0012

System Description and Operation

Individual Filter Operation

Online Operation: Flow through each Filter is determined by the Overall Plant Flow Set-point. This will be total flow to the Rapid Mix basins divided by the number of online filters.

FILTER FLOW S.P.= (FIT28010101 + FIT28020101)/(# ONLINE FILTERS)

Normal flow through the filter is through Filter Influent Valve FV300X0101 through the filter itself, and through Effluent Flow Control Valve FCV300X0105 and Effluent Isolation Valve FV300X0106. (X = 1,2,3,4)

BACKWASH:

A Filter Backwash can be initiated by the operator from SCADA or the Local OIT at the Filter PLC cabinet located in the Process building. For Operator initiated Backwash the Operator would first need to bring a Standby Filter online prior to backwashing the filter. The filters can also be configured for automatic backwash initiation. The auto backwash can be initiated on High Turbidty, High Differential Pressure, or Time between backwashes.

Automatic Backwash Prerequisites:

1. Sufficient volume available in Backwash Waste Ponds as indicated by LIT42010101. Max allowable pond level [TBD]
2. Sufficient Volume in the Finished Water Wet Well associated with the selected BWS Pump
3. Duty Air Scour Blower BLW30000X01 X=1,2 selected by Operator. At least one blower available.
4. Backwash Supply Pump PMP360X0501 X=1,2) selected by Operator. At least one BWS Pump available.

Operator adjusts the following parameters:

High D/P S.P. [TBD] OPERATOR SELECTABLE. High D/P indicated by PDIT300X0101

High TURBIDITY S.P. [TBD] OPERATOR SELECTABLE. High Turbidity is indicated by AIT300X0101

Backwash Time [TBD] OPERATOR SELECTABLE. Operator enters Low BW Flow Duration , High BW Flow Duration,

Low Speed Backwash Flow [TBD] OPERATOR SELECTABLE. Operator enters Min BW Flow

Low Speed Backwash Duration [TBD] OPERATOR SELECTABLE

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High Speed Backwash Flow [TBD] OPERATOR SELECTABLE. Operator enters Max BW Flow

High Speed Backwash Duration [TBD] OPERATOR SELECTABLE

Air Scour Flow Set-point [TBD] OPERATOR SELECTABLE. Operator enters Air Scour Flow

Note: Air Scour Flow determined by FCV3000301 Position with feedback from FIT30000302

BACKWASH SEQUENCE

(X=1,2,3,4)

Filter Influent Valve FV300X0101 Closes

Filter Effluent Isolation Valve FV300X0106 Closes

Filter Effluent Control Valve FCV300X0105 Closes

Duty Backwash Pump PMP360X0501 Starts at Min Speed

Filter Backwash Supply Valve FV300X0103 Opens

Filter Backwash Waste Valve FV300X0102 opens

Backwash Pump ramps to Minimum Backwash Flow

Air Scour Blower Starts

Filter Air Scour Isolation Valve FV300X0104 Opens

Air Scour Blower Control Valve FCV30000301 Slowly closes to direct scour air to Filter

Backwash Pump and Air Scour run at Low Speed Backwash Flow for Low Speed Backwash Duration. At the end of Low Speed Backwash The Air Scour Valve ramps open and the Air Scour Blower Stops.

Duty Backwash Pump Ramps to High Speed Flow Set-point for the High Speed Backwash Duration. Pump then ramps to minimum speed.

Filter Backwash Waste Valve FV300X0102 Closes

Filter To Waste Valve FV300X0107 Opens.

Backwash Pump Ramps to 50 percent for [TBD} minutes as final flush

Backwash Pump ramps down and stops

Filter Backwash Supply Valve FV300X0103 Closes

Filter To Waste Valve FV300X0107 Closes

Filter Influent Valve FV300X0101 Opens, Filter fills to normal operating level

Note: If Backwashed Filter is put back online the following steps occur. Otherwise Filter can stay offline until the next filter is backwashed

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Filter Effluent Isolation Valve FV300X0106 Opens

As Filter Level nears normal operating range, Filter Effluent Control Valve FCV300X0105 ramps to maintain Filter Flow Set-point.

Automatic Control

Filter X (X=1,2,3,4)

- Program Flow Control Set-points for FCV300X0105 at Plant SCADA
- Program LOCAL-ON-OFF-REMOTE status at Plant SCADA for All valves.
- Program LEVEL set-points at Plant SCADA.
- Program LEVEL indication at Plant SCADA.
- Program Differential Pressure indication at Plant SCADA.
- Program Differential Pressure set-points at Plant SCADA.
- Program Turbidity Indication at Plant SCADA.
- Program Turbidity set-points at Plant SCADA.

GAC Filter Operation

Th GAC supplied Pumps will be controlled by a Vendor Supplied Control System which will receive Hard Wired commands from Plant SCADA. Th GAC system will be used for Plant Flows less than 1 MGD. Two manual valves must be opened prior to initiating GAC operation.

Operator adjusts/selects the following parameters

GAC Flow Setpoint (.25 to 1 MGD)

GAC Lead, LAG, and STBY pumps

GAC Adsorber Online Vessel, one online one standby

Backwash Initiation Set-Point (D/P monitored by DPIT3001050X, X=1,2) in Psig

Note: GAC Filter Backwash pre-requisites: Sufficient Volume in the backwash Ponds and sufficient Clearwell level.

SCADA Calculates the following:

GAC System set-point (.25 to 1 MGD)= Rapid Mix Flow for any online Rapid Mix Basins

Normal Flow through the GAC system is from the online GAC supply pump, through the selected GAC Adsorber to the Finished water wet well. The following pump and valve sequence applies:

Initially all GAC automated valves are closed with both manual system isolation valves closed. \

The operator opens the manual feed and return isolation valves.

For the following X=1,2)

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SCADA operator selects GAC system operation (GAC supply Pump and Adsorber vessel selections have already been made and GAC system and GAC supply pump skid is in Auto)

Valve FV28010X02 Vessel 1 Effluent Valve OPENS

GAC Supply Pump Starts at min speed

Valve FV28010X01 Vessel 1 Influent Valve OPENS

Section – Finished water Pump Station

Process Unit/Facility is Finished Water Facility FW. Facility number is 360.

Process Overview

The Finished water pump stations primary function is to provide finished water to Regulation Tank No. 3, The Finished water pump station also serves as the water source for Filter Backwash Water, GAC Backwash Water , the Potable Water System and the Fire Suppression System. Water can be recycled back to the front of the plant from an actuated valve off the backwash supply pump discharge.

Finished Water Pumps 1 and 2 draw out of Finished Water Wet Well 1, and Finished Water Pumps 3 and 4 draw out of Finished Water Wet Well 2. Both sets of pumps are Duty/ Standby and VFD driven. All finished water pumps shall be interlocked with surge tank isolation valve and shall not be allowed to run when valve is in the closed position.

Backwash Pump 1 draws out of Wet Well 1 Backwash Pump 2 draws out of Wet Well 2. Both Pumps are VFD driven and operate as Duty /Standby.

The finished water pipeline can be drained through a plunger valve back into the finished water pump station influent channel.

Plunger valve will be used to start up and test the finished water pumps.

References

Drawing	Description
008-I-0013	Potable Water and Fire Suppression P&ID
008-I-0014	Finished water PS and Surge Tank P&ID
008-I-0015	Surge Tank P&ID

Equipment

Equipment	Description	Drawing
PMP360010101	Domestic Water Pump 1	080-I-0013
PMP360010102	Domestic Water Pump 2	080-I-0013
PMP500010201	Fire Suppression Pump 1	080-I-0013
PMP36010301	Domestic Water Sample Pump	080-I-0013

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Equipment	Description	Drawing
PMP36010401	Finished Water Pump 1	080-I-0014
PMP36010403	Finished Water Pump 2	080-I-0014
PMP36020401	Finished Water Pump 3	080-I-0014
PMP36020403	Finished Water Pump 4	080-I-0014
PMP36020501	Backwash Supply Pump 1	080-I-0014
PMP36010501	Backwash Supply Pump 2	080-I-0014
PMP36030403	Finished water Sample Pump	080-I-0014
FV36010402	Finished Water Pump 1 Discharge Valve	080-I-0014
FV36010404	Finished Water Pump 2 Discharge Valve	080-I-0014
FV36020402	Finished Water Pump 3 Discharge Valve	080-I-0014
FV36020404	Finished Water Pump 4 Discharge Valve	080-I-0014
FV36010502	Backwash Supply Pump 1 Discharge Valve	080-I-0014
FV36020502	Backwash Supply Pump 2 Discharge Valve	080-I-0014
FV36030502	Combined Well Discharge to Filters	080-I-0014
FV36030503	Combined Well Discharge to Plant Influent	080-I-0014
TNK36010802	Surge Tank	080-I-0015

Instrument

Instrument	Description	Drawing
LIT36010101	Domestic Water Well Level	080-I-0013
LIT50010101	Fire Water Well Level	080-I-0013
LIT36010601	Finished water Level 1	080-I-0014
LIT36020601	Finished water Level 2	080-I-0014
FIT36030401	Finished Water Flow to Tank 3	080-I-0014
FIT36030501	Backwash Flow To Filters	080-I-0014

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System Description and Operation

Finished Water Pumps – PMP3600X0401, 403 (X=1, 2)

Finished water from the Finished Water Wet Well 1 and 2 can be pumped to Tank T3 for distribution to the system. Each Wet Well serves two Finished Water Pumps, each VFD driven. Pumps will be Duty/Standby and operate on Level control (LIT360X0601, X=1,2) to maintain Wet Well Level while also monitoring Tank T3 level to prevent overfilling or underfilling T3.

Bioreactor Basins incorporate combined PEFF/RAS (mixed liquor) flow control weir gate leading to its AX zones. Weir Gates are provided with LOCAL-REMOTE local control station (LCS) and motor control. When not in REMOTE, OPEN-CLOSE (POSITION) control is provided at the control station. In REMOTE, OPEN-CLOSE (POSITION) control is provided by Plant SCADA.

Plant SCADA monitors LOCAL-REMOTE status and POSITION indication of each gate. Plant monitors channel level and calculates flow over weirs based upon level and gate position.

Channel LEVEL and Gate POSITION are monitored and used to maintain calculated flow set-points. Plant SCADA modulates gate POSITIONS to maintain equal flow over each GATE and MAXIMUM FLOW RATE.

Plant SCADA calculates Flow over Weir Gates (BRB-ML-FI-030-0X, X=1,2,3) and compares flow rate with plant secondary effluent flow as measured by DIS-PLEEF-055-01 located at Disinfection Facility.

Plant SCADA ALARMS when measured flows over Bioreactor Gates deviates by more than 15 percent for an adjustable period of time from measured flows at Disinfection Facility. Flow at Disinfection Facility is measured by instrument DIS-PLEEF-055-01. Deviation and time set-points are adjusted by Operator at Plant SCADA.

Note: The intent of this alarm to confirm correction factors for Weir Gates located at Bioreactor Basin and Effluent Junction Box No. 3.

Interlocks (Hardware and Software): NA.

Backwash Supply Pumps – PMP360010501 (X=1, 2,)

Mixers are provided with ON-OFF-REMOTE local control station (LCS) and constant speed motor control. When not in REMOTE, RUN control is provided at the control station. In REMOTE, RUN control is provided by Plant SCADA.

Plant SCADA monitors ON-OFF-REMOTE and ON-OFF status indication of each mixer.

Plant SCADA RUN mixers when levels in basins are above LOW LEVEL condition.

Interlocks (Hardware and Software): Plant SCADA monitors equipment safety instrumentation and STOPS equipment (remove RUN command) in the event of the following Alarm conditions: PUMP or VALVE FAILURE, LEAK/TEMPERATURE and LOW LEVEL. Alarm RESET performed at local control station, motor control, or package system control panel as described in PLC Standard Programming Functions.

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Flow and pressure set-points will be sent to packaged blower control system.

- Set-point and indication at Plant SCADA.
- Program ALARM status at Plant SCADA.
- Program STANDARD FUNCTIONS as defined by Project Applications Software Standards.

Section – OFF Spec/ Backwash Pond

Process Unit/Facility is Off Spec/Backwash Pond Facility. Facility number is 420/440.

Process Overview

Filter To Waste, Plant Drains, Backwash Waste, and sludge form each Flocculation Basin is routed to the Off/Spec/Backwash Waste pond through the BWW Pond Influent Box and then through automated gates to Train 1 Sludge Collector and Train 2 Sludge Collector into the Sludge Transfer Station. Anionic Polymer is added at the Sludge Transfer Station. Sludge Transfer Pump 1 and 2 pumps pump the sludge to the Solids Drying Pond

The Sludge Collectors are Packaged Systems.

References

Drawing	Description
008-I-0016	Off Spec/Backwash Pond P&ID

Equipment

Equipment	Description	Drawing
SLC42010101	Sludge Collector 1	080-I-0016
SLC42010102	Sludge Collector 2	080-I-0016
PMP42010104	Sludge Collector Pump 1	009-I-0016
PMP42020104	Sludge Collector Pump 2	009-I-0016
GTE42010101	BWW Pond Influent Box Gate to BWW Pond 1	009-I-0016
GTE42020101	BWW Pond Influent Box Gate to BWW Pond 2	009-I-0016
FV42010103	Sludge Collector 1 Discharge Valve	009-I-0016
FV42020103	Sludge Collector 2 Discharge Valve	009-I-0016

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Instrument

Instrument	Description	Drawing
LIT42010001	BWW INFLUENT BOX LEVEL	009-I-0016
LIT42010002	SLUDGE TRANSFER STATION LEVEL	009-I-0016
FIT42010003	SLUDGE FLOW TO SOLIDS DRYING PONDS 1&2	009-I-0016

System Description and Operation

Sludge Collector SLC42010X02 (X=1,2)

See Section 44 46 10, Sludge Collection Equipment, for more information on the Sludge Collectors.

The Sludge Collectors are packaged systems. Each Sludge Collector can be started and stopped form Plant SCADA when in Auto. The Sludge Collector Speed can also be controlled form Plant SCADA when in Auto. Each Sludge Collector at the Sludge Collector Station will have a Local Control Panel with an OIT. Local Hand Switches will be located at the Sludge Collector itself. Sludge Collector speed will be set by the plant operator. Each Sludge Collector will have an automated sludge discharge valve that will open or close based on the running status of the sludge collector.

Sludge is pumped by the Sludge Collectors to the Sludge Collecting station, while water is decanted off the top of the Backwash Waste Ponds to the Decant Station.

Sludge Flow to the drying ponds is monitored by FIT42010003. Sludge flows are totalized daily, weekly, and monthly and displayed at SCADA.

Sludge Transfer Pumps – PMP420X0104 (X=1,2)

The Sludge Transfer Pumps will operate Duty/Standby. Duty/Standby selection will be made by the plant operator from Plant SCADA. Each Pump is VFD driven. The Duty pump will vary it's speed to maintain a level setpoint at the sludge transfer station (LIT42010002). High Level at the Drying Ponds will prohibit operation of the transfer pumps.

Automatic Control

Sludge Collectors – SLC420X0102 (X=1,2)

- Program REMOTE SCADA-AUTO/MANUAL control at Plant SCADA.
- Program ALARM status at Plant SCADA.
- Program REMOTE SCADA-Speed Control and Speed Indication at Plant SCADA

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Sludge Transfer Pumps – SC420X0102 (X=1,2)

- Program REMOTE SCADA-AUTO/MANUAL control at Plant SCADA.
- Program ALARM status at Plant SCADA.
- Program REMOTE SCADA-Speed Control and Speed Indication at Plant SCADA
- Program Duty/ Standby Selection at Plant SCADA
- Program Level Control Set-point at Plant SCADA

Backwash Waste Pond Isolation Gates – GTE420X0101 (X=1,2)

- Program REMOTE SCADA-AUTO/MANUAL control at Plant SCADA.
- Program ALARM status at Plant SCADA.

FIT42010003 Sludge Flow to Drying Ponds)

- Program Flow Indication, Totalization and Fail Alarm Status at Plant SCADA.

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Section – Decant Pump Station

Process Unit/Facility is Decant Pump Station DEC. Facility number is 460.

Process Overview

Pioneer Effluent Pump Station sends disinfected secondary effluent from the Midland Water Pollution Control Plant (WPCP) to Pioneer Water Management (BE) for beneficial reuse. Effluent flow is pumped from the pump station to a reservoir that supplies the final reuse destinations.

Pioneer Effluent Pump Station also sends pressurized W3 service water to various new and existing processes. These processes include existing influent rotary drum screens, screw presses, polymer secondary dilution, wash-down, sluice trough, washer/compactor, grit pump flushing, clarifier sprays, and plant-wide hose stations.

Automatic Self-cleaning strainer removes grit from W3 service water flows.

Pioneer Water Management (BE) communicates flow demand requirements with City of Midland via phone. Plant Operators at Midland Water Pollution Control Plant (WPCP) ENABLE-DISABLE and ADJUST FLOW set-points to secondary treatment and diversion structure according to communicated demand requirements.

When secondary flow rate decreases to ZERO, various processes operating based upon DIS-PLEEF-FIT-050-01 measurements will STOP.

References

Drawing	Description
009-I-0017	Decant Pump Stations P&ID

Equipment

Equipment	Description	Drawing
PMP46010101	Environmental Discharge Pump 1	080-I-0017
PMP46011202	Environmental Discharge Pump 2	080-I-0017
PMP46010103	Environmental Discharge Pump 3	080-I-0017
FV46010002	Decant Pump Station Inlet Valve 1	009-I-0017
FV46010003	Decant Pump Station Inlet Valve 2	009-I-0017

Instrument

Instrument	Description	Drawing
LIT46010004	Decant Pump Station Level	009-I-0017
FIT46010004	Decant Pump Station Effluent Flow	009-I-0017

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System Description and Operation

Environmental Discharge/Recycle Pumps – PMP4601010X (X=1, 2, 3)

The Env Discharge pumps are provided with variable frequency drive (VFD) motor control. When not in REMOTE, RUN and SPEED control is provided at the VFD. In REMOTE, RUN and SPEED control is provided by Plant SCADA.

Plant SCADA monitors ON-OFF-REMOTE status and SPEED indication of each motor drive. SCADA monitors motor TEMPERATURE and LEAK indication instrumentation.

Decant is normally sent to the NPDES Discharge Point. Decant can also recycled to the head of the plant. Up to 10 percent of the plant Influent flow can be recycled. Manual valves will be need to be repositioned to redirect flow.

Env Discharge pumps are continuously operated in a DUTY1, DUTY2, STANDBY configuration to maintain LEVEL set-point within Decant Pump Station Wet Well. LEVEL set-points (START, STOP ALL PUMPS, LEVEL S.P.HIGH, and HIGH-HIGH) are adjusted by Operator at Plant SCADA.

- Plant SCADA STARTs and STOPs pumps based upon level inside wet well and pump speed. PLC operates and modulates DUTY pump speeds to maintain wet well level. DUTY1 and DUTY2 pumps will vary speed together. If an operating DUTY pump fails, the STANDBY pump is started and ramps to 50 percent speed, the remaining DUTY pump also ramps to 50 percent the two pumps then modulate together to maintain wet well level. If wet well level drops below the LWCO, the PLC will STOP both pumps. When wetwell level rises to the pump SATRT level, both duty pumps will be restarted.
- Operator assigns DUTY1, DUTY2, STANDBY order at Plant SCADA to maintain equal runtime.

Total Decant/Recycle effluent flow rate will be measured with a magnetic flowmeter FIT46010004.

Recycle Mode

When in Recycle mode. The manual valve to the NPDES discharge point will be closed and the manual valve to the front of the plant will be opened. The plant operator will place the Env Discharge Pumps in Recycle mode. In this mode the two DUTY pumps will operate to recycle 10 percent of the combined plant Influent flow back to the Rapid Mix Basins. Flow Setpoint will = 0.1 X (FIT28010101 +FIT28020101) as indicated by FIT46010004.

Section – Chemical Facility

Process Unit/Facility is Chemical Facility SFA, FC, SHC, SH, CPO, APO, PHA, and CDS. Facility number is 380.

Process Overview

As water flows through the plant from Influent to effluent, the following chemicals are added at the following five points:

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1. Ferric Chloride (FeCl) and Sulfuric Acid (SFA) at the Rapid Mix Basin, FeCl as a coagulant. Operator to judge effectiveness through lab results. 30 mg/L ferric chloride dose SFA for Ph control to enhance the effectiveness of FeCl. A target of 6.0 is recommended.
2. Anionic Polymer at the Floc Sedimentation Basins as a Flocculant. Effectiveness judge by visual assessment by operator. Anionic Polymer Pumps 4, 5, and 6 are dedicated to the Flocc Sed Basins.
3. Cationic/Nonionic Polymer and Sodium Hydroxide (NaOh) prior to the filters. Polymer as a Flocculant aid. NaOh for Ph control.
4. Phosphoric Acid (PO4), Carbon Dioxide(CDS), Sodium Hydroxide (NaOh), and Sodium Hypochlorite (SHC) prior to the Finished water wet well.

   PO4 for lead and copper corrosion control

   CDS To account for alkalinity

   NaOh Ph Control

   SHC as a Disinfectant
5. Anionic Polymer is added at the Backwash Ponds to aid in settling the sludge at the drying ponds.

   Anionic Polymer Pumps 1& are dedicated to the Backwash Ponds

   Chemical Solution Strengths:

   40% FeCl
   93% Sulfuric Acid
   75% Phosphoric Acid
   50% NaOh
   10% SHC
   .5% All Polymers

References

Drawing	Description
008-I-0019	Sulfuric Acid Storage and Feed P&ID
008-I-0020	Ferric Chloride Storage and Feed P&ID
008-I-0021	Sodium Hypochlorite Storage and Feed P&ID
008-I-0022	Sodium Hydroxide Storage and Feed P&ID
008-I-0023	Nonionic/Cationic Polymer Storage and Feed P&ID
008-I-0024	Anionic Polymer Storage and Feed P&ID
008-I-0025	Anionic Polymer Feed Pumps 1&2 P&ID

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Drawing	Description
008-I-0026	Anionic Polymer Feed Pumps 3-6 P&ID
008-I-0027	Phosphoric Acid Storage and Feed P&ID
008-I-0028	Carbon Dioxide Storage and Feed P&ID
008-I-0029	Chem Fill and Truck Spill Containment P&ID

Equipment

Equipment	Description	Drawing
PMP38010101	Sulfuric Acid Metering Pump 1	080-I-0019
PMP38010102	Sulfuric Acid Metering Pump 3	080-I-0019
PMP38010103	Sulfuric Acid Metering Pump 3	080-I-0019
TNK38010001	Sulfuric Acid Bulk Storage Tank	080-I-0019
PMP38020101	Ferric Chloride Metering Pump 1	080-I-0020
PMP38020102	Ferric Chloride Metering Pump 2	080-I-0020
PMP38020103	Ferric Chloride Metering Pump 3	080-I-0020
TNK38020001	Ferric Chloride Bulk Storage Tank	080-I-0020
PMP38030101	SHC Metering Pump 1	080-I-0021
PMP38030102	SHC Metering Pump 1	080-I-0021
TNK38030001	SHC Bulk Storage Tank	080-I-0021
PMP38040101	Sodium Hydroxide Metering Pump 1	080-I-0022
PMP38040102	Sodium Hydroxide Metering Pump 2	080-I-0022
PMP38040103	Sodium Hydroxide Metering Pump 3	080-I-0022
TNK38040001	Sodium Hydroxide Bulk Storage Tank	080-I-0022
TNK38050101	Nonionic or Cationic Mixing Tank 1	080-I-0023
TNK38050102	Nonionic or Cationic Mixing Tank 2	080-I-0023
MXR38050101	Nonionic or Cationic Mixing Tank 1 Mixer	080-I-0023
MXR38050102	Nonionic or Cationic Mixing Tank 2 Mixer	080-I-0023
PMP38040101	Non/Cationic Polymer Feed Pump 1	080-I-0023

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Equipment	Description	Drawing
PMP38040102	Non/Cationic Polymer Feed Pump 2	080-I-0023
TNK38050001	Nonionic or Cationic Tote	080-I-0023
PMP38050106	Non/Cationic Polymer Blending Pump 1	080-I-0023
PMP38050107	Non/Cationic Polymer Blending Pump 2	080-I-0023
PBU38050101	Non/Cationic Polymer Blending Unit 1	080-I-0023
PBU38050102	Non/Cationic Polymer Blending Unit 2	080-I-0023
FV38050101	Non/Cationic Mix Tank 1 Inlet Valve	080-I-0023
FV38050103	Non/Cationic Mix Tank 2 Inlet Valve	080-I-0023
FV38050102	Non/Cationic Mix Tank 1 Outlet Valve	080-I-0023
FV38050104	Non/Cationic Mix Tank 2 Outlet Valve	080-I-0023
TNK38060101	Anionic Mixing Tank 1	080-I-0024
TNK38060102	Anionic Mixing Tank 2	080-I-0024
MXR38060101	Anionic Mixing Tank 1 Mixer	080-I-0024
MXR38060102	Anionic Mixing Tank 2 Mixer	080-I-0024
FV38060101	Anionic Mix Tank 1 Inlet Valve	080-I-0024
FV38060103	Anionic Mix Tank 2 Inlet Valve	080-I-0024
FV38060102	Anionic Mix Tank 1 Outlet Valve	080-I-0024
FV38060104	Anionic Mix Tank 2 Outlet Valve	080-I-0024
PMP38060101A	Anionic Polymer Blending Pump 1	080-I-0024
PMP38060102A	Anionic Polymer Blending Pump 2	080-I-0024
PBU38060101	Anionic Polymer Blending Unit 1	080-I-0024
PBU38060102	Anionic Polymer Blending Unit 2	080-I-0024
TNK38060001	Anionic Tote No. 1	080-I-0024
TNK38060002	Anionic Tote No. 2	080-I-0024
PMP38060101	Anionic Polymer Feed Pump 1	080-I-0025
PMP38060102	Anionic Polymer Feed Pump 2	080-I-0025
PMP38060103	Anionic Polymer Feed Pump 3	080-I-0026

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Equipment	Description	Drawing
PMP38060104	Anionic Polymer Feed Pump 4	080-I-0026
PMP38060105	Anionic Polymer Feed Pump 5	080-I-0026
PMP38070101	Phosphoric Acid Feed Pump 1	080-I-0027
PMP38070102	Phosphoric Acid Feed Pump 2	080-I-0027
PMP38070103	Phosphoric Acid Feed Pump 3	080-I-0027
TNK38070001	Phosphoric Acid Tote No. 1	080-I-0027
PMP38080201	Carrier Water Pump 1	080-I-0028
PMP38080202	Carrier Water Pump 2	080-I-0028
MC38080101	Pressurized Solution Feed Panel	080-I-0028

Instruments

Instrument	Description	Drawing
PE38010101	Sulfuric Acid Tank Level Element	080-I-0019
LIT38010101	Sulfuric Acid Tank Level Transmitter	080-I-0019
FIT38010101	Rapid Mix Basin 1 SFA Flow Rate	080-I-0019
FIT38010102	Rapid Mix Basin 2 SFA Flow Rate	080-I-0019
PE38020101	FeCl Tank Level Element	080-I-0020
LIT38020101	FeCl Tank Level Transmitter	080-I-0020
FIT38020101	Rapid Mix Basin 1 FeCl Flow Rate	080-I-0020
FIT38020102	Rapid Mix Basin 2 FeCl Flow Rate	080-I-0020
PE38030101	SHC Tank Level Element	080-I-0021
LIT38030101	SHC Tank Level Transmitter	080-I-0021
FIT38030101	Filter Seal Weir SHC Flow Rate	080-I-0021
PE38040101	SHC Tank Level Element	080-I-0022
LIT38040101	SHC Tank Level Transmitter	080-I-0022
LSH38041101	NAOH CONTAINMENT SUMP HIGH LEVEL	080-I-0022

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System Description and Operation

1 FeCl and SFA injection at Rapid Mix Basins

The goal is to inject FeCl at 30 mg/L at a target pH of 6.0.FeCl into Rapid Mix Basin 1 and 2. The SFA dose will be determined by the FeCl dose. Since FeCl also lowers pH, as the FeCl dose goes up, the SFA does will go down

For a FeCl dose of 20 mg/L, SFA will be dosed at 31.9 mg/L (at pH 6.0)

For a FeCl dose of 30 mg/L, SFA will be dosed at 22.1 mg/L (at pH 6.0)

For a FeCl dose of 40 mg/L, SFA will be dosed at 12.3 mg/L (at pH 6.0)

FeCl Dosing

FeCl will be flow paced off the appropriate Rapid Mix Influent Flow Meter FIT280X0101 (X=1,2).

Operator adjusts the following parameters:

Dosage Rate (mg/L).

Manual Stroke adjustment at pump, also enter this value on the SCADA setup screen for each chem add pump. 0 to 100 percent. This sets the volume delivered on each pump stroke.

Solution concentration. The concentration of the FeCl solution.

Specific gravity of the solution.

Dosage Loop Control for FeCl:

In Auto mode, based on the four parameters above and the Rapid Mix Basin Influent Flow Rate

The PLC calculates the required pump speed according to the following equation:

q=Q*d/(sg*C*24),

q=Chem flow in gal/hr.

Q=Rapid Mix Basin Influent Flow in MGD

d=dose rate in mg/L,

sg=specific gravity,

C=concentration of chemicals in percentage.

The PLC sends this signal to the pump VFD. A pump curve showing pump stroke on the X axis and pump delivery rate per pump stroke on the Y-axis will be developed based on

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calculated back pressure. Values from this curve will be programmed into the PLC. The PLC will then calculate the required speed to deliver the required dose.

Adjustable Ratio Range: 0 to 100 percent SPEED.

Initial Setting: 0 percent.

Ferric Chloride Metering Pumps – PMP3802010X (X=1, 2, 3)

The Ferric Chloride Metering Pumps are provided with HAND-OFF AUTO at the Vendor Local Control Panel When not in AUTO, RUN control is provided at the LCP. In AUTO, RUN control is provided by Plant SCADA.

Plant SCADA monitors HAND-OFF-AUTO status of each motor.

Operator will select a FeCl Pump for each Rapid Mix Basin. The remining pump will serve as a Standby pump to either of the two.

Dosage Loop Control for SFA:

SFA Dose will follow the FeCl dose as follows:

For a FeCl dose of 30 mg/L, SFA will be dosed at 22.1 mg/L (at pH 6.0).

SFA dose will be trimmed by the Ph reading from the effluent of the appropriate Flocc/Sed Basin Effluent ph analyzer AIT280X0601 (X=1,2) to maintain 6.0 to maximize the effectiveness of the FeCl.

Operator adjusts the following parameters

Dosage Rate (mg/L).

Manual Stroke adjustment at pump, also enter this value on the SCADA setup screen for each chem add pump. 0 to 100 percent. This sets the volume delivered on each pump stroke.

Solution concentration. The concentration of the SFA solution.

Specific gravity of the solution.

In Auto mode, based on the four parameters above and the Rapid Mix Basin Influent Flow Rate

the PLC calculates the required pump speed according to the following equation:

q=Q*d/(sg*C*24),

q=Chem flow in gal/hr,

Q=Rapid Mix Basin Influent Flow in MGD

d=dose rate in mg/L,

sg=specific gravity,

C=concentration of chemicals in percentage.

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The PLC sends this signal to the pump VFD. A pump curve showing pump stroke on the X axis and pump delivery rate per pump stroke on the Y-axis will be developed based on calculated back pressure. Values from this curve will be programmed into the PLC. The PLC will then calculate the required speed to deliver the required dose.

Auto: Speed Control.

Operator adjusts the following parameters:

Automatic Control

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SECTION 40 99 90
PACKAGE CONTROL SYSTEMS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. The Institute of Electrical and Electronics Engineers, Inc. (IEEE): C62.41, IEEE Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits.
2. International Society of Automation (ISA): S50.1, Compatibility of Analog Signals for Electronic Process Instruments.
3. National Electrical Manufacturers Association (NEMA):
   a. 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
   b. AB 1, Molded Case Circuit Breakers and Molded Case Switches.
   c. ICS 2, Industrial Control Devices, Controllers and Assemblies.
4. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
5. Underwriters Laboratories Inc. (UL): 508A, Standards for Safety, Industrial Control Panels.

1.02 SYSTEM DESCRIPTION

A. Assemble panels and install instruments, plumbing, and wiring in equipment manufacturer's factories.

B. Test panels and panel assemblies for proper operation prior to shipment from equipment manufacturer's factory.

C. Test panels and panel assemblies for proper operation in field.

D. Provide hardware, software, tools, test equipment, testing forms, documentation, and personnel necessary to coordinate and support CH2M HILL with PCS Component Testing and Integration of PCS with overall Plant Process Instrumentation and Control System (PICS).

E. Coordinate all programming with CH2M HILL prior to factory testing and shipment of equipment to field and during onsite testing.

F. Participate in Application Software Workshops at CH2M HILL's Office located in Englewood, Colorado to coordinate the following software requirements:

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1. Coordinate programming roles and responsibility.
2. Review P&IDs, loop descriptions, and package system controls and functionality.
3. PLC programming.
4. PLC to PLC communication.
5. OIT to PLC communication programming.
6. OIT display and display navigation programming.
7. OIT database programming.
8. OIT control pop-ups programming.
9. OIT set-point pop-ups programming.
10. OIT trends programming.
11. OIT alarm programming.
12. OIT security programming.
13. Tagging and device designation and functionality.
14. Factory Demonstration Testing (FDT) and Component testing and sequence of activities.
15. Instrument ranges and settings.
16. Panel and loop drawings.
17. IO listing and assignments.
18. Assembly of all documentation.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings, Bill of Material, catalog information, descriptive literature, wiring diagrams, and Shop Drawings for components of control system.
2. Catalog information on electrical devices furnished with system.
3. Shop Drawings, catalog material, and dimensional layout drawings for control panels and enclosures.
4. Panel elementary diagrams of prewired panels. Include in diagrams control devices and auxiliary devices, for example, relays, alarms, fuses, lights, fans, and heaters.
5. Plumbing diagrams of pre-plumbed panels and interconnecting plumbing diagrams.
6. Interconnection wiring diagrams that include numbered terminal designations showing external interfaces.

B. Informational Submittals:

1. Factory Demonstration, Staging Site, Functional, and Performance Testing.
2. Owner’s Training.
3. Record Drawings.

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4. Programmable Controller Submittals:
    a. Complete set of user manuals.
    b. PLC and HMI applications software including:
        1) PLC configuration, tag naming conventions, data tables, programming sections, memory mapping, tag addressing, ranges, scaling, and cross references.
        2) PLC Input-Output (IO) list with content and format specified herein.
        3) Fully documented PLC ladder diagrams, ladder logic, and standard and derived function block programming.
        4) Cross-reference listing.
        5) As-built programmable control software configuration for the package control system that was developed using the programmable controller's software development tool.
        6) Process communications (PLC, RTU, RIO, SCADA, and Ethernet IP).
5. Manufacturer's list of proposed spares, expendables, and test equipment.
6. Manufacturer's Certificate of Proper Installation in accordance with Section 01 43 33, Manufacturers' Field Services.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Prior to shipment, include corrosive-inhibitive vapor capsules in shipping containers and related equipment as recommended by capsule manufacturer.

1.05 EXTRA MATERIALS

A. Spares, Expendables, and Test Equipment:

1. Selector Switch, Pushbutton, and Indicating Light: 20 percent, one minimum, of each type used.
2. Light Bulb: 100 percent, 2 minimum, of each type used.
3. Fuse: 100 percent, 5 minimum, of each type used.
4. Surge Suppressors: 20 percent, one minimum, of each type used.

PART 2 PRODUCTS

2.01 CORROSION PROTECTION

A. Corrosion-Inhibiting Vapor Capsule Manufacturers:

1. Northern Instruments; Model Zerust VC.
2. Pentair-Hoffman; Model A-HCI.

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2.02 PROGRAMMABLE LOGIC CONTROLLER (PLC)

A. Provide Modicon M340 PLCs and TBD Operating Interface Units (OIU) communicating via Ethernet with Plant SCADA (PLC and HMI) System unless otherwise noted.

B. The Owner's standard Modicon M340 PLCs and components as of the date of this Basis of Design Report. Examples of acceptable IO cards and communications modules can be found in Section 40 92 05, Programmable Logic Controllers, Supplement 1.

2.03 SOFTWARE REQUIREMENTS

A. Provide all necessary software licenses to allow programming, operation, and maintenance of the package control system.

B. Licenses shall cover all software including PLC programming, HMI configuring, operating systems, and networking. Use Schneider Electric Unity Pro XL software for PLC programming

C. Applications Software: Applications software program code and software configuration information for PLCs, HMIs and network components shall be non-proprietary and fully documented to allow the Owner to interface with and to operate, program configure and maintain the software.

2.04 PLC NETWORK INTERFACE

A. PLCs will communicate with Plant PLCs and HMI computers over Plant SCADA Ethernet local area network (LAN) and as shown on Communications Block Diagrams. PLCs will communicate with VFDs, Motor Starters, and MCCs over Ethernet Networks using Modbus TCP/IP protocol unless otherwise noted.

B. Data Exchange:

1. Schneider Electric Unity Pro XL software for PLC programming for Vendor supplied PLCs.
2. Network message traffic shall be controlled by the Plant PLCs and SCADA. Read and Write message instructions shall be executed by the Plant PLCs and SCADA. Package Control System PLCs **shall not perform write** commands with other PLCs on the network, only read.
3. Provide network communication failure monitoring and detection with a heartbeat signal.
4. Organize data values to be exchanged into contiguous register blocks. On block for each of the following types:
   a. Analog data to be sent.
   b. Analog data to be received.

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c. Discrete data to be sent.
d. Discrete data to be received.

5. Format for Analog Values: Engineering units using double precision floating point format.
6. Format for Discrete Values: 16-bit binary words (representing 16 unique status of alarm conditions.)

C. Provide a data exchange an additional list coordinating PLC and SCADA communications with the following columns:

1. Description: A description of each set-point or control point.
2. Interface Type: Read, Write, Analog, and Discrete, Real, or Integer.
3. Engineering Range: 0, 1 for Discrete; 0 to Maximum for Analog.
4. Engineering Units: Fahrenheit (F), FEET, MGD, GPM, Gallons, PSI, PSIG, PPM, %, and MG/L.
5. Tag Name: The tag name in the PLC and SCADA database.

D. Coordination and Testing:

1. Provide dedicated time for coordinating final data point definitions with the Owner and PIC's integrator.
2. Provide on-site testing and startup time devoted to data exchange testing, massage validation and network timing validation with Plant SCADA PLCs.

2.05 PLC IO LIST AND TAG NAMES

A. Provide an input/output (IO) list for each PLC with the following columns:

1. Description: A description of each IO point.
2. IO Type: Choice of Analog Input (AI), Analog Output (AO), Digital Input (DI), Digital Output (DO).
3. Engineering Range: 0,1 for Discrete; 0 to Maximum for Analogs.
4. Engineering Units: Feet, GPM, Gallons, PSIG, PPM, and MG/L.
5. PLC Number. PLC reference number two characters.
6. ISA designation.
7. Site Area.
8. Group Number.
9. Loop Sequence Number.
10. Tag Suffix.
11. IO Name: the point address in the PLC database.
12. Chassis Slot: Slot the IO Point is terminated.
13. Point Number: IO Point number.
14. Comments.

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2.06 UNINTERRUPTIBLE POWER SUPPLY

A. PLC, HMI and network switches shall be powered from 120V branch circuits originating at UPS panelboards being provided as part of Division 26 work.

2.07 INSTRUMENTATION

A. Provide instrumentation as defined in Section 40 91 00, Instrumentation and Control Components, unless otherwise noted.

2.08 CONTROL PANEL

A. Panel Construction and Interior Wiring: In accordance with the National Electrical Code (NEC), UL 508, state and local codes, and applicable sections of NEMA, ANSI, and ICECA.

B. Conform to NEMA ratings as specified in individual equipment sections.

C. Minimum Metal Thickness: 14-gauge.

D. Provide Ethernet Interface capability for passing and receiving SCADA commands and information.

E. Provide Ethernet signal interface list.

F. Provide Ethernet switch, switch to be supported by Facility UPS.

G. NEMA 250:

1. Type 4X Panels: Type 316 stainless steel construction for outdoor and process areas unless otherwise specified.
2. Type 12 Panels: painted steel construction for indoor environmentally controlled electrical room unless otherwise specified.

H. Doors:

1. Type 4X: Stainless steel quick release clamps.
2. Type 12: Three-point latching mechanisms for panels with doors higher than 18 inches.

I. Cutouts shall be cut, punched, or drilled and finished smoothly with rounded edges.

J. Access: Front, suitable for installation with back and sides adjacent to or in contact with other surfaces, unless otherwise specified.

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K. Temperature Control:

1. Size panels to adequately dissipate heat generated by equipment mounted on or in the panel.
2. Furnish cooling fans with air filters if required to dissipate heat.
3. For panels outdoors or in unheated areas, furnish thermostatically controlled heaters to maintain temperature above 40 degrees F.

L. Push-to-Test Circuitry: For each push-to-test indicating light, provide a fused push-to-test circuit.

M. Lighting: Minimum of one hand switch controlled internal 100-watt incandescent light for panels 12 cubic feet and larger.

N. Minimum of one 120-volt GFCI duplex receptacle for panels 12 cubic feet and larger.

O. Finish:

1. Metallic External Surfaces (Excluding Aluminum and Stainless Steel): Manufacturer's standard gray unless otherwise specified.
2. Internal Surfaces: White enamel.

P. Panel Manufacturers:

1. Pentair-Hoffman.
2. H.F. Cox.

Q. Breather and Drains: Furnish with NEMA 250, Type 4 and 4X panels.

1. Manufacturer and Product: Cooper Crouse-Hinds; ECD Type 4X Drain and Breather; Drain Model ECD1-N4D, Breather Model ECD1-N4B.

R. Terminal Blocks:

1. General:
    a. Connection Type: Screw compression clamp.
    b. Compression Clamp:
        1) Complies with DIN-VDE 0611.
        2) Hardened steel clamp with transversal grooves that penetrate wire strands providing a vibration-proof connection.
        3) Guides strands of wire into terminal.
    c. Screws: Hardened steel, captive, and self-locking.
    d. Current Bar: Copper or treated brass.

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e. Insulation:
    1) Thermoplastic rated for minus 55 degrees C to plus 110 degrees C.
    2) Two funneled shaped inputs to facilitate wire entry.
f. Mounting:
    1) Standard DIN rail.
    2) Terminal block can be extracted from an assembly without displacing adjacent blocks.
    3) End Stops: Minimum of one at each end of rail.
g. Wire Preparation: Stripping only permitted.
    1) Heat shrink the ends of all shielded and multi-conductors cables prior to termination of individual conductors.
h. Instrument Grounds: Collect all grounding for DC instruments and shielded cables to a common grounding bus that is isolated from panel enclosure and bonded to the control panel equipment grounding bus by a single 8 AWG copper conductor.
i. Jumpers: Allow jumper installation without loss of space on terminal or rail.
j. Marking System:
    1) Terminal number shown on both sides of terminal block.
    2) Allow use of preprinted and field marked tags.
    3) Terminal strip numbers shown on end stops.
    4) Mark terminal block and terminal strip numbers as shown on panel control diagrams and loop diagrams.
    5) Fuse Marking for Fused Terminal Blocks: Fuse voltage and amperage rating shown on top of terminal block.

2. Terminal Block, General Purpose:
    a. Rated Voltage: 600V ac.
    b. Rated Current: 30 amps.
    c. Wire Size: 24 AWG to 10 AWG.
    d. Rated Wire Size: 10 AWG.
    e. Color: Gray body.
    f. Spacing: 0.25 inch, maximum.
    g. Manufacturers and Products:
        1) Phoenix Contact; Type UT4/UT4-TWIN.
        2) Entrelec; Type M4/6.T.
        3) Or equal.
3. Terminal Block, Ground:
    a. Wire Size: 24 AWG to 10 AWG.
    b. Rated Wire Size: 10 AWG.
    c. Color: Green and yellow body.
    d. Spacing: 0.25 inch, maximum.
    e. Grounding: Electrically grounded to mounting rail.

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f. Manufacturers and Products:
1) Phoenix Contact; Type UT4-PE-UT4-TWIN-PE.
2) Entrelec; M4/6.P.
3) Or equal.

4. Terminal Block, Blade Disconnect Switch:
a. Rated Voltage: 600V ac.
b. Rated Current: 10 amps.
c. Wire Size: 22 AWG to 10 AWG.
d. Rated Wire Size: 10 AWG.
e. Color: Gray body, orange switch.
f. Spacing: 0.25 inch, maximum.
g. Manufacturers and Products:
1) Phoenix Contact; Type UT4-PE-UT4-TWIN-PE.
2) Entrelec; M4/6.SNT.
3) Or equal.

5. Terminal Block Diode:
a. Rated Voltage: 24V dc.
b. Rated Current: 30 mA.
c. Wire Size: 16 AWG.
d. Manufacturers and Products:
1) Phoenix Contact, Type ST-IN.
2) Or equal.

6. Terminal Block, Fused, 24V dc:
a. Rated Voltage: 600V dc.
b. Rated Current: 25 amps.
c. Wire Size: 22 AWG to 10 AWG.
d. Rated Wire Size: 10 AWG.
e. Color: Gray body.
f. Fuse: 0.25 inch by 1.25 inches.
g. Indication: LED diode 24V dc.
h. Spacing: 0.512 inch, maximum.
i. Manufacturers and Products:
1) Schneider Electric/Square D.
2) Phoenix Contact; Type UT6-HESILED (24).
3) Entrelec; Type ML10/13/SFD.
4) Or equal.

7. Terminal Block, Fused, 120V ac:
a. Rated Voltage: 600V ac.
b. Rated Current: 25 amps.
c. Wire Size: 22 AWG to 10 AWG.
d. Rated Wire Size: 10 AWG.
e. Color: Gray body.
f. Fuse: 0.25 inch by 1.25 inches.
g. Indication: Neon lamp, 110V ac.
h. Leakage Current: 1.8 mA, maximum.
i. Spacing: 0.512 inch, maximum.

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j. Manufacturers and Products:
    1) Schneider Electric/Square D.
    2) Phoenix Contact; Type UT6-HESILED (250).
    3) Entrelec; Type ML10/13.SFL.
    4) Or equal.

8. Terminal Block, Fused, 120V ac, High Current:
    a. Rated Voltage: 600V ac.
    b. Rated Current: 35 amps.
    c. Wire Size: 18 AWG to 8 AWG.
    d. Rated Wire Size: 8 AWG.
    e. Color: Gray.
    f. Fuse: 13/32 inch by 1.5 inches.
    g. Spacing: 0.95 inch, maximum.
    h. Manufacturers and Products:
        1) Schneider Electric/Square D.
        2) Phoenix Contact; Type UK10.3-HESILED.
        3) Entrelec; MB10/24.SF.
        4) Or equal.

S. Relays:

1. General:
    a. Relay Mounting: Plug-in type socket.
    b. Relay Enclosure: Furnish dust cover.
    c. Socket Type: Screw terminal interface with wiring.
    d. Socket Mounting: Rail.
    e. Provide hold down clips.
2. Signal Switching Relay:
    a. Type: Dry circuit.
    b. Contact Arrangement: 2 Form C contacts.
    c. Contact Rating: 5 amps at 28V dc or 120V ac.
    d. Contact Material: Gold or silver.
    e. Coil Voltage: As noted or shown.
    f. Coil Power: 0.9 watt (dc), 1.2VA (ac).
    g. Expected Mechanical Life: 10,000,000 operations.
    h. Expected Electrical Life at Rated Load: 100,000 operations.
    i. Indication Type: Neon or LED indicator lamp.
    j. Seal Type: Hermetically sealed case.
    k. Manufacturers and Products:
        1) Potter and Brumfield; Series KH/KHA.
        2) IDEC; Series RR.
3. Control Circuit Switching Relay, Nonlatching:
    a. Type: Compact general purpose plug-in.
    b. Contact Arrangement: 3 Form C contacts.
    c. Contact Rating: 10A at 28V dc or 120V ac, and 6.6A at 240V ac.
    d. Contact Material: Silver cadmium oxide alloy.

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e. Coil Voltage: As noted or shown.
f. Coil Power: 1.8 watts (dc), 2.7VA (ac).
g. Expected Mechanical Life: 10,000,000 operations.
h. Expected Electrical Life at Rated Load: 100,000 operations.
i. Indication Type: Neon or LED indicator lamp.
j. Push-to-test button.
k. Manufacturers and Products:
    1) Potter and Brumfield; Series KUP.
    2) IDEC; Series RR.

4. Control Circuit Switching Relay, Latching:
    a. Type: Dual coil mechanical latching relay.
    b. Contact Arrangement: 2 Form C contacts.
    c. Contact Rating: 10A at 28V dc or 120V ac.
    d. Contact Material: Silver cadmium oxide alloy.
    e. Coil Voltage: As noted or shown.
    f. Coil Power: 2.7 watts (dc), 5.3VA (ac).
    g. Expected Mechanical Life: 500,000 operations.
    h. Expected Electrical Life at Rated Load: 50,000 operations.
    i. Manufacturers and Products:
        1) Potter and Brumfield; Series KB/KBP.
        2) IDEC; Series RR2KP.
5. Control Circuit Switching Relay, Time Delay:
    a. Type: Adjustable time delay relay.
    b. Contact Arrangement: 2 Form C contacts.
    c. Contact Rating: 10A at 30V dc or 277V ac.
    d. Contact Material: Silver cadmium oxide alloy.
    e. Coil Voltage: As noted or shown.
    f. Operating Temperature: Minus 10 degrees C to 55 degrees C.
    g. Repeatability: Plus or minus 2 percent.
    h. Delay Time Range: Select range such that time delay setpoint fall between 20 percent to 80 percent of range.
    i. Time Delay Setpoint: As noted or shown.
    j. Mode of Operation: As noted or shown.
    k. Adjustment Type: Integral potentiometer with knob external to dust cover.
    l. Manufacturers and Products:
        1) Potter and Brumfield; Series CB for 0.1-second to 100-minute delay time ranges, Series CK for 0.1-second to 120-second delay time ranges.
        2) IDEC; Series RTE/GT3.

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T. Surge Suppressors:

1. General:
   a. Construction: First-stage high-energy metal oxide varistor and second-stage bipolar silicon avalanche device separated by Series impedance; includes grounding wire, stud, or terminal.
   b. Response: 5 nanoseconds maximum.
   c. Recovery: Automatic.
   d. Temperature Range: Minus 20 degrees C to plus 85 degrees C.
2. Suppressors on 120V ac Power Supply Connections:
   a. Occurrences: Tested and rated for a minimum of 50 occurrences of IEEE C62.41 Category B test waveform.
   b. First-Stage Clamping Voltage: 350 volts or less.
   c. Second-Stage Clamping Voltage: 210 volts or less.
   d. Continuous Operation: Power supplies for one four-wire transmitter or receiver: 5 amps minimum at 130V ac. All other applications: 30 amps minimum at 130V ac.
3. Suppressors on Analog Signal Lines:
   a. Test Waveform: Linear 8 microsecond rise in current form 0 amps to a peak current value followed by an exponential decay of current reaching one-half the peak value in 20 microseconds.
   b. Surge Rating: Tested and rated for 50 occurrences of 2,000-amp peak test waveform.
      1) dc Clamping Voltage: 20 percent to 40 percent above operating voltage for circuit.
      2) dc Clamping Voltage Tolerance: Less than plus or minus 10 percent.
      3) Maximum Loop Resistance: 18 ohms per conductor.
4. Physical Characteristics:
   a. Mounted in Enclosures: Encapsulated inflame retardant epoxy.
   b. For Analog and DC Discrete Signals Lines:
      1) EDCO PC-642 or SRA-64 Series.
      2) Phoenix Contact; Plugtrab PT or TT Series.
   c. For 120V ac Discrete Lines:
      1) EDCO HSP-121,
      2) Phoenix Contact; Plugtrab PT or TT Series.
   d. Field Mounted at Two-Wire Instruments: Encapsulated in stainless steel pipe nipples.
      1) EDCO SS64 Series.
      2) Phoenix Contact; SPD Series.
   e. Field Mounted at Four-Wire Instruments: With 120V ac outlet, ac circuit breaker, and 10-ohm resistors on signal lines, all in enclosure.
      1) Enclosure:
         a) NEMA 4X fiberglass or Type 316 stainless steel with door.

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b) Maximum Size: 12 inches by 12 inches by 8 inches deep.

2) Manufacturers and Products:
   a) EDCO; SLAC Series.
   b) Transector; ACP Series.
   c) Phoenix Contact; BXT Series.
   d) Innovative Technologies.

U. Power Supplies:

1. Furnish as required to power instruments requiring external dc power, including two-wire transmitters and dc relays. Provide dual power supplies with diode auctioneered outputs.
2. Convert 120V ac, 60-Hz power to dc power of appropriate voltage(s) with sufficient voltage regulation and ripple control to assure that instruments being supplied can operate within their required tolerances.
3. Provide output over voltage and over current protective devices to:
   a. Protect instruments from damage due to power supply failure.
   b. Protect power supply from damage due to external failure.
4. Enclosures: NEMA 1.
5. Mount such that dissipated heat does not adversely affect other components.
6. Fuses: For each dc supply line to each individual two-wire transmitter.
   a. Type: Indicating.
   b. Mount so fuses can be easily seen and replaced.
7. Manufacturers and Products:
   a. Power-One; O-Din, W-Din Series.
   b. Phoenix Contact; Quint-PS.
   c. Sola; Son Series.
   d. Puls; QS5.DNET, QS10.DNET.
   e. Or equal.

V. Intrinsic Safety Barriers:

1. Intrinsically Safe Relays: Monitor discrete signals that originate in hazardous area and are used in a safe area.
   a. Manufacturers and Products:
      1) Phoenix Contact; ME Series.
      2) Turck; IM1, MK Series.
2. Intrinsically Safe Barriers: Interface analog signals as they pass from hazardous area to safe area.
   a. Manufacturers and Products:
      1) Phoenix Contact; ME Series.
      2) Turk; IM1, MK Series.

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2.09 CONTROL PANEL ELECTRICAL

A. UL Listing Mark for Enclosures: Mark stating “Listed Enclosed Industrial Control Panel” per UL 508A.

B. I&C and electrical components, terminals, wires, and enclosures UL recognized or UL listed.

C. Control Panels without Motor Starters:

1. Furnish main circuit breaker and a circuit breaker on each individual branch circuit distributed from power panel.
2. Locate to provide clear view of and access to breakers when door is open. Group on single subpanel. Provide typed directory.
3. Circuit Breakers:
    a. Coordinate for fault in branch circuit trips, branch breaker, and not main breaker.
    b. Branch Circuit Breakers: 15 amps at 250V ac.
    c. Breaker Manufacturers and Products:
        1) Heineman Electric Co.; Series AM.
        2) Airpax/North American Philips Controls Corp.; Series 205.

D. Control Panels with Three-Phase Power Supplies, Motor Starters, and Variable Frequency Drives:

1. Assemble control panels with section and barrier separating three-phase power equipment (power supplies, motor starters, and variable frequency drives) from instrumentation and control equipment (PLC, HMI, discrete and analog devices).
2. Provide three-phase equipment with a minimum 42,000-ampere RMS symmetrical rating at 480 Volts unless otherwise required per Section 26 05 70, Electrical Systems Analysis.
3. Provide control panels with Arc Flash Warning Labels in accordance with Section 26 05 70, Electrical Systems Analysis.
4. Interlock main circuit breaker with panel door.
    a. Mount logic controls, branch circuit breakers, overload reset switches, and other control circuit devices.
    b. Mount operator controls and indications on front access door.
5. Circuit Breakers:
    a. In accordance with NEMA AB 1.
    b. 42,000-ampere RMS symmetrical, minimum at 480 volts, unless otherwise specified.
    c. Breakers, except Motor Branch Breakers: Molded case thermal magnetic.
    d. Tripping: Indicate with operator handle position.

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6. Provide Motor Control meeting the requirements of Section 26 24 19, Low-Voltage Motor Control, including:
    a. Magnetic Motor Starters:
        1) Full voltage, NEMA ICS 2, Class A, Size 1 minimum.
        2) Solid State (Electronic) overload relays rated for each motor with Ethernet/IP communications.
        3) Reset button mounted on panel door.
    b. Motor Control: 120V ac (except intrinsically safe circuits where applicable).
        1) Power Control Transformer:
            a) Sufficient capacity to serve connected load, including 200VA for duplex outlet plus 100VA (minimum).
            b) Limit voltage variation to 15 percent during contact pickup.
            c) Fuse one side of secondary winding and ground the other.
            d) Furnish primary winding fuses in ungrounded conductors.
7. Provide Variable Frequency Drives meeting the requirements of Section 26 29 23, Low-Voltage Variable Frequency Drive System, including:
    a. Drive unit.
    b. Drive protection.
    c. Drive current protection fuses.
    d. Human Interface Module (HIM).
    e. Rectifier.
    f. Controller.
    g. Harmonic Mitigation: Line Reactors, Load Reactors
    h. Control and Signal Interface supporting Ethernet IP communications
8. Under Voltage Relay:
    a. Protect single phase equipment from low voltage.
    b. Separate, isolated contact outputs to stop equipment and activate alarm light during abnormal conditions.
    c. Transient Voltage Protection: 10,000 volts.
    d. Manufacturer and Product: Potter & Brumfield; CS Series.
9. Power Monitoring Relay:
    a. Protect three-phase equipment from single phasing, phase imbalance, or phase reversal.
    b. Separate, isolated contact outputs to stop motors and activate alarm light during abnormal conditions.
    c. Transient Voltage Protection: 10,000 volts.
    d. Manufacturer and Product: Symcom; Model 777.
10. Power Distribution Blocks: Furnish to parallel feed tap on branch circuit protective devices. Do not “leap frog” power conductors.

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11. Terminations for Power Conductors: Suitable for use with 75 degrees C wire at full NFPA 70, 75 degrees C ampacity.

E. Front-of-Panel Devices in Conjunction with NEMA 250, Type 12 Panels:

1. Potentiometer Units:
   a. Three-terminal, oiltight construction, resolution of 1 percent and linearity of plus or minus 5 percent.
   b. Single-hole, panel mounting accommodating panel thicknesses between 1/8 and 1/4 inch.
   c. Include legend plates with service markings.
   d. Manufacturers and Products:
      1) Allen-Bradley; Model 800T.
      2) Eaton/Cutler-Hammer; Model 10250T.
2. Indicating Lights:
   a. Heavy-duty, push-to-test type, oiltight, industrial type with integral transformer for 120V ac applications.
   b. Screwed on prismatic glass lenses in colors noted and factory engraved legend plates for service legend.
   c. Manufacturers and Products:
      1) Eaton/Cutler-Hammer; Type 10250T.
      2) General Electric; CR2940U.
3. Pushbutton, Momentary:
   a. Heavy-duty, oiltight, industrial type with full guard and momentary contacts rated for 10 amperes continuous at 120V ac.
   b. Standard size legend plates with black field and white markings for service legend.
   c. Manufacturers and Products:
      1) Square D; Class 9001, Type K.
      2) Eaton/Cutler-Hammer; Type T.
      3) General Electric; Type CR-2940.
4. Selector Switch:
   a. Heavy-duty, oiltight, industrial type with contacts rated for 120V ac service at 10 amperes continuous.
   b. Standard size, black field, legend plates with white markings, for service legend.
   c. Operators: Black knob type.
   d. Single-hole mounting, accommodating panel thicknesses from 1/16 inch to 1/4 inch.
   e. Manufacturers and Products for Units with up to Four Selection Positions:
      1) Eaton/Cutler-Hammer; Type T.
      2) Square D; Type K.

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f. Manufacturers and Products for Units with up to 12 Selection Positions:
    1) Rundel-Idec; Standard Cam Switch.
    2) Electroswitch; 31.

F. Front-of-Panel Devices Used in Conjunction with NEMA 250, Type 4X Panels:

1. Potentiometer, Watertight:
    a. Three-terminal, heavy-duty NEMA 250, Type 4X watertight construction, resolution of 1 percent and linearity of plus or minus 5 percent.
    b. Single-hole, panel mounting accommodating panel thicknesses between 1/8 and 1/4 inch.
    c. Include engraved legend plates with service markings.
    d. Manufacturer and Product: Allen-Bradley; Bulletin 800H.
2. Indicating Lights, Watertight:
    a. Heavy-duty, push-to-test type, NEMA 250, Type 4X watertight, industrial type with integral transformer for 120V ac applications and corrosion-resistant service.
    b. Screwed on prismatic lenses and factory engraved legend plates for service legend.
    c. Manufacturers and Products:
        1) Square D; Type SK.
        2) Allen-Bradley; Type 800H.
3. Pushbutton, Momentary, Watertight:
    a. Heavy-duty, NEMA 250, Type 4X watertight, industrial type with momentary contacts rated for 120V ac service at 10 amperes continuous and corrosion-resistant service.
    b. Standard size, black field, legend plates with white markings for service legend.
    c. Manufacturers and Products:
        1) Square D; Type SK.
        2) Allen-Bradley; Type 800H.
4. Selector Switch, Watertight:
    a. Heavy-duty, NEMA 250, Type 4X watertight, industrial type with contacts rated for 120V ac service at 10 amperes continuous and corrosion-resistant service.
    b. Standard size, black field, legend plates with white markings, for service legend.
    c. Operators: Black knob type.
    d. Single-hole mounting, accommodating panel thicknesses from 1/16 to 1/4 inch.
    e. Manufacturers and Products:
        1) Square D; Class 9001, Type SK.
        2) Allen-Bradley; Type 800H.

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2.10 INSTRUMENT TAG NUMBERS

A. A shorthand tag number notation is used. For example:

AI-X-Y-ZN[pH]

Notation	Explanation
AI	ISA designator for Analysis Indicator
X	Site Area
Y	Group Number
Z	Loop Number
N	Set Letter used when there are multiple devices with the same unit number
[pH]	Same notation shown at 2 o'clock position on ISA circle symbol on Process and Instrument Diagram.

2.11 NAMEPLATES, NAMETAGS, AND SERVICE LEGENDS

A. As defined in the applicable Process Specifications.

B. Nametags: Permanently mounted bearing entire ISA tag number.

1. Panel Mounted: Plastic, mounted to instrument behind panel face.
2. Field Mounted: Engraved Type 316 stainless steel, 22-gauge minimum thickness, attached with stainless steel.

C. Service Legends (Integrally Mounted with Instrument) and Nameplates:

1. Engraved, rigid, laminated plastic type with adhesive back. Furnish service legends and nameplates to adequately describe functions of panel face mounted instruments.
2. Color: White with black letters.
3. Letter Height: 3/16 inch.
4. For each panel, face mounted laminated nameplate inscribed with the panel name and tag number. Color shall be white with black letters 1/2 inch high.

D. Standard Light Colors and Inscriptions: Unless otherwise specified in individual equipment specifications, use the following color code and inscriptions for HMI and indicators, unless otherwise noted:

Tag	Inscription(s)	Color
RUNNING	RUNNING	Green
ON	ON	Green

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Tag	Inscription(s)	Color
OFF	OFF	Red
OPENED	OPENED	Green
CLOSED	CLOSED	Red
LOW	LOW	Red
FAIL	FAIL	Red
HIGH	HIGH	Red
COMPUTER	COMPUTER	Blue
SCADA-MANUAL	SCADA-MANUAL	Yellow
SCADA-AUTO	SCADA-AUTO	Yellow
FORWARD	FORWARD	Red
REVERSE	REVERSE	Blue

1. Lettering: Black on white and amber lenses; white on red and green lenses.
2. Standard Pushbutton Colors and Inscriptions:
   a. Use following unless otherwise noted:

Tag Function	Inscription(s)	Color
OO	ON OFF	Black Black
OC	OPEN CLOSE	Black Black
OCA	OPEN CLOSE AUTO	Black Black Black
OCC	OPEN CLOSE COMPUTER	Black Black Black
OOA	ON OFF AUTO	Black Black Black
OOC	ON OFF COMPUTER	Black Black Black

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Tag Function	Inscription(s)	Color
LOC	LOCAL OFF COMPUTER	Black Black Black
SS	START STOP	Black Black
RESET	RESET	Black
EMERGENCY STOP	EMERGENCY STOP	Red

b. Lettering Color:
   1) Black on white and yellow buttons.
   2) White on black, red, and green buttons.

2.12 ELECTRICAL SURGE AND TRANSIENT PROTECTION

A. Equip control panels with surge-arresting devices to protect equipment from damage as a result of electrical transients induced in interconnecting lines from lightning discharges and nearby electrical devices.

B. Suppressor Locations:

1. At point of connection between an equipment items, including ac powered transmitters, and power supply conductor (direct-wired equipment).
2. On analog pairs at each end when the pair travels outside of building.
3. In other locations where equipment sensitivity to surges and transients requires additional protection beyond that inherent to design of equipment.

C. Suppressor Design:

1. Construction: First-stage, high-energy metal oxide varistor and second-stage, bipolar silicon avalanche device separated by series impedance; includes grounding wire, stud, or terminal.
2. Response: 5 nanoseconds maximum.
3. Recovery: Automatic.
4. Temperature Range: Minus 20 degrees C to plus 85 degrees C.
5. Enclosure Mounted: Encapsulated inflame retardant epoxy.

D. Suppressors on 120V ac Power Supply Connections:

1. Occurrences: Tested and rated for a minimum of 50 occurrences of IEEE C62.41 Category B test waveform.

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2. First-Stage Clamping Voltage: 350 volts or less.
3. Second-Stage Clamping Voltage: 210 volts or less.
4. Power Supplies for Continuous Operation:
    a. Four-Wire Transmitter or Receiver: Minimum 5 amps at 130V ac.
    b. All Other Applications: Minimum 30 amps at 130V ac.

E. Suppressors on Analog Signal Lines:

1. Test Waveform: Linear 8-microsecond rise in current from 0 amps to a peak current value followed by an exponential decay of current reaching one-half the peak value in 20 microseconds.
2. Surge Rating: Tested and rated for 50 occurrences of 2,000-amp peak test waveform.
    a. dc Clamping Voltage: 20 percent to 40 percent above operating voltage for circuit.
    b. dc Clamping Voltage Tolerance: Plus or minus 10 percent.
    c. Maximum Loop Resistance: 18 ohms per conductor.

F. Manufacturers and Products:

1. Analog Signals Lines: Emerson Edco PC-642 or SRA-64 series.
2. 120V ac Lines: Emerson Edco HSP-121.
3. 480-Volt, Three-Phase Power Supplies: Square D Model SDSA3650.
4. Field Mounted at Two-Wire Instruments:
    a. Encapsulated in stainless steel pipe nipples.
    b. Emerson Edco SS64 series.
5. Field Mounted at Four-Wire Instruments: With 120V ac outlet, ac circuit breaker, and 10-ohm resistor on signal line, all in enclosure.
    a. Enclosure:
        1) NEMA 4X Type 316 stainless steel with door.
        2) Maximum Size: 12 inches by 12 inches by 8 inches deep.
    b. Emerson Edco; SLAC series.

G. Grounding:

1. Coordinate surge suppressor grounding in field panels and field instrumentation as specified in Section 26 05 26, Grounding and Bonding for Electrical Systems, and suppressor manufacturer’s requirements.
2. Provide control panels with an integral copper grounding bus for connection of suppressors and other required instrumentation.
3. Grounding buses and terminal strips for DC instruments and shielded cables shall be isolated from the control panel enclosure and bonded to the control panel’s equipment grounding bus by a single 8 AWG copper conductor.

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PART 3 EXECUTION

3.01 ELECTRICAL POWER AND SIGNAL WIRING

A. Restrain control and signal wiring in control panels by plastic ties or ducts. Secure hinge wiring at each end so bending or twisting will occur around the longitudinal axis of wire. Protect bend area with a sleeve.

B. Arrange wiring neatly, cut to proper length, and remove surplus wire. Install abrasion protection for wire bundles passing through holes or across edges of sheet metal.

C. Use manufacturer's recommended tool with sized anvil for crimp terminations. No more than one wire may be terminated in a single crimp lug. No more than two lugs may be installed on a single screw terminal.

D. Do not splice or tap wiring except at device terminals or terminal blocks.

3.02 PROTECTION

A. Protect enclosures and other equipment containing electrical, instrumentation and control devices, including spare parts, from corrosion through the use of corrosion-inhibiting vapor capsules.

B. During Work, periodically replace capsules in accordance with capsule manufacturer's recommendations. Replace capsules at Substantial Completion.

END OF SECTION

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SECTION 41 22 23.19
MONORAIL HOISTS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American National Standards Institute (ANSI): MH27.1, Underhung Cranes and Monorail Systems.
2. American Society of Mechanical Engineers (ASME):
   a. B30.10, Hooks.
   b. B30.11, Monorails and Underhung Cranes.
   c. HST 1M, Performance Standard for Electric Chain Hoists.
   d. HST 2M, Performance Standard for Hand Chain Manually Operated Chain Hoists.
   e. HST 4M, Performance Standard for Overhead Electric Wire Rope Hoists.
3. National Electrical Manufacturer's Association (NEMA):
   a. MG 1, Motors and Generators.
   b. 250, Enclosures for Electrical Equipment (1,000 volts maximum).
4. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
5. Occupational Safety and Health Act (OSHA).
6. Underwriters Laboratory (UL): 674, Electric Motors and Generators for Use in Division 1 Hazardous (Classified) Locations.

1.02 DESIGN REQUIREMENTS

A. Monorail System: Specifications for Underhung Cranes and Monorail Systems, ANSI MH27.1 and ASME B30.11.

B. Hoist: ASME B30.11, Hoist Manufacturers' Institute.

C. Trolley: ANSI MH27.1.

D. Wire Rope Hoist Service Class: ASME HST 4M.

E. Hook: ASME 30.10.

F. Stress and Safety Factors: ANSI MH27.1 and ASME B30.11. Properly select materials of construction for stresses to which subjected.

G. Safety of Operation, Accessibility, Interchangeability, and Durability of Parts: ASME B30.11 and OSHA requirements.

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H. Provide system, equipment, and components, including supports and anchorages, designed in accordance with Section 01 61 00, Common Product Requirements.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Make, model, weight, and horsepower of each equipment assembly.
   b. Complete catalog information, descriptive literature, materials of construction, and specifications on hoist, wheels, gears and bearing, trolley drive system, hoist motor and assemblies, hook, brakes, starting system, variable speed drive system, conductors (bus bar, festoon, cable reel), controls, remote control system, and accessories.
   c. Structural design calculations for monorail track and support system and calculations of deflection and loads on building steel stamped by a registered professional engineer in the State of New Mexico.
   d. Detail Shop Drawings of monorail track, brackets, hangers, and their attachments to building structural steel.
   e. Power and control wiring diagrams, including terminals and numbers.
   f. Motor nameplate data in accordance with NEMA MG 1, and include any motor modifications.
   g. Factory finish system.

B. Informational Submittals:

1. Special shipping, storage and protection, and handling instructions.
2. Manufacturer’s printed installation instructions.
3. Manufacturer’s Certification of Compliance that factory finish system is identical to requirements specified herein.
4. Factory Functional Test Report.
5. Suggested spare parts list to maintain the equipment in service for a period of 1 year. Include a list of special tools required for checking, testing, parts replacement, and maintenance with current price information.
6. List special tools, materials, and supplies furnished with equipment for use prior to and during startup and for future maintenance.
7. Operation and Maintenance Data: As specified in Section 01 78 23, Operation and Maintenance Data.
8. Manufacturer’s Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers’ Field Services.

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1.04 ENVIRONMENTAL REQUIREMENTS

A. Temperature: Maximum 85 degrees F; minimum 55 degrees F.

B. Humidity: 100 percent.

PART 2 PRODUCTS

2.01 GENERAL

A. Hoist and trolley manufacturer to coordinate equipment requirements with steel structures, drive motor, hoisting cable or chain, hook, track, stops, and electrical equipment controls.

B. Where adjustable speed drives or remote-control systems are required, crane manufacturer to furnish a coordinated operating system.

2.02 SUPPLEMENTS

A. See supplements to this section for additional requirements.

2.03 TRACK

A. Furnish monorail track in accordance with Section 05 12 00, Structural Steel Framing.

B. Track Design Criteria:

1. Steel track structural design shall conform to AISC 360, as applicable.
2. Cross-Section: Design for stresses not exceeding 60 percent of material's yield strength and deflection not to exceed 1/800 of span.
3. Span: Not to exceed 45 feet with one load per span used in computing total capacity of track. Ratio of span to top flange width shall not exceed 60 to 1 for spans over 16 feet. Lower load-carrying flange minimum of 3-1/4-inch width and have raised running or wear tread.
4. Couplings: Web type at track joints with maximum gap at track ends of load-carrying flange of 1/16 inch and 3/16 inch at turntable, switch, or free ends.
5. Stops: Furnish stops and impact-absorbing bumpers at open track ends.
6. Design for vertical force increased by 25 percent for impact.
7. Design for longitudinal force of 10 percent of vertical force.
8. Design for torsional forces caused by eccentric loading, lateral forces, or offset connections.
9. Consider fatigue and stress on bottom flange due to wheel loading.

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C. Track Suspension:

1. Furnish clamps, hanger rods, and fittings to support live and dead load of hoist, trolley, controls, motors, and track.
2. Hanger Rods: High carbon, cold-rolled alloy steel with unified national fine, Class 2 screw thread ends.
3. Vertical Adjustment: 1 inch adjustable.
4. Lubricant: Permanent factory prelubricated joints.

2.04 TROLLEY

A. Frame: Welded steel, cast steel, or ductile iron construction, or a combination thereof. Construct to control deflection of trolley assembly while transmitting the carrying load to running surface.

B. Drive shall consist of trolley drive shaft, driven by an electric motor through a gear reduction unit.

C. Furnish roller assembly stabilizers on single-girder trolley units to prevent tipping during load pickup.

D. Wheels: Rolled or forged steel, accurately machined and ground to receive inner bearing races. Furnish alloy steel axles. Rotating axles with wheels mounted press fit and keys, or with keys alone. Minimum tread hardness 210 Brinell.

E. Drive Gears: Helical, spur or herringbone type, rolled or cast steel, with machine cut teeth.

F. Bearings: Combination radial and thrust type, double row, angular contact ball bearings or single-row tapered roller bearings. Bearings prelubricated and sealed, or fitted for pressure lubrication. Locate pressure lubrication fittings for accessibility during maintenance.

G. Brakes: Suitable for service class and rated torque capacities as specified in ASME B30.11.

2.05 HOIST

A. Hoisting machinery shall consist of rope drum driven through gear reductions, load blocks, hook, hoisting rope, sheaves, and hoist braking. Drum size and length sufficient for minimum two turns of cable remaining on drum when hook is at lowest position. Furnish reeving as specified on Supplements at end of section. Provide right and left-hand grooved drum when two-part double reeving is specified.

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B. Rope drum and surrounding members constructed to minimize abrasion, crushing or jamming of hoist rope. Load blocks enclosed type. Hoisting rope extra flexible, improved plow steel wire rope, made especially for hoist service.

C. Hook: Construct with sufficient ductility to open noticeably before hook failure, equipped with safety latch, free to rotate 360 degrees with rated load and positively held in place with locknuts, collars or other devices.

D. Brakes: Mechanical and electric load brake and controls, designed in accordance with ASME 4M, and adjustable to compensate for wear.

E. Brakes: In accordance with ASME HST 1M and ASME HST 2M, adjustable to compensate for wear, spring set, electric release load brake system, which releases load when drive motor is energized and holds load when the drive motor is de-energized.

2.06 ELECTRICAL

A. Furnish electrical equipment including motors, motor starters, pendant control, control systems, wire, and conduit.

B. Electrical: In accordance with NFPA 70, NEC Article 610.

C. Furnish motors compatible with adjustable frequency, variable speed, drive system, 40 to 1 speed range, suitable for hoist, trolley, and bridge drive applications. Controls with 120V ac, microprocessor based, pulsed width modulation design, withstand 45 degree C temperatures, housed in NEMA 250, Type **4** enclosure, and supplied with 200 percent overcurrent protection.

1. Manufacturers and Products:
   a. P & H Smartorque**.**
   b. Approved equal.

D. Monorail conductor voltage drops from monorail track supply taps shall permit the hoist and trolley motors to operate within voltage tolerances of plus or minus 10 percent, when building supply voltage is at plus or minus 5 percent of design voltage.

E. Festooned Flat Cable Conductors: Flexible cable, carried by heavy-duty roller, permanently lubricated roller bearings, with monorail support system that will dispense and retrieve flexible cable without twisting or tangling, and 20 percent spare conductor in each cable assembly.

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F. Cable Reel Conductors: Flexible cable, housed on a circular wheel, counter-torque spring to dispense and retrieve cable, with sag not more than 3 feet below connection point on hoist or trolley at maximum travel.

G. Grounding: External in accordance with NFPA 70, NEC Article 250.

2.07 CONTROLS

A. Hoist and Trolley: Pendant control having momentary contact pushbuttons with a device which will disconnect motors from line on failure of power. Device shall not permit any motor to be restarted until controller handle is brought to the OFF position, or a reset switch or button is operated. Furnish with undervoltage protection as a function of each motor controller, or by magnetic main line contactor.

B. Pushbuttons: Fully magnetic, plain reversing type, housed in NEMA 250, Type 12 enclosure, with contactors of sufficient size and quantity for starting, accelerating, reversing, and stopping duty for specified hoist service class.

C. Trolley Drives: Soft start controls, 460/230V ac series device, installed between drive motor and motor starter with torque and acceleration rate adjustable, suitable for trolley drive service, and work in conjunction with crane control and pendant system.

D. Pendant Pushbutton Control Stations: Heavy-duty, oil-tight, suspended from trolley, with control transformers to supply 120V ac power to pushbutton control station. Pushbutton enclosure supported with chain or wire rope. Control wire cable attached to support chain or wire rope at not more than 6-foot intervals. Furnish control station buttons for control of hoist and trolley ON/OFF main line contactor power switch which removes all power from control station.

2.08 ACCESSORIES

A. Equipment Identification Plate: 16-gauge stainless steel with 1/4-inch die-stamped equipment tag number securely mounted in a readily visible location.

B. Lifting Lugs: Equipment weighing over 100 pounds.

2.09 FACTORY FINISHING

A. Prepare and prime coat in accordance with manufacturer’s standard industrial finish system.

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2.10 SOURCE QUALITY CONTROL

A. Factory Inspections: Inspect control panels and equipment for required construction, electrical connection, and intended function.

B. Factory Tests and Adjustments: No-load run test all equipment furnished.

C. Factory test report shall include Test Data Sheets.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer's printed instructions.

B. Provide lubrication and lubrication fittings.

3.02 FIELD FINISHING

A. Repair damaged finishes per manufacturer's recommendations.

3.03 FIELD QUALITY CONTROL

A. Functional Tests: Conduct on each hoist and monorail system.

1. Alignment: Test complete assemblies for proper alignment and connection, and quiet operation.

B. Performance Test:

1. Conduct on each hoist and monorail system.
2. Load tests in compliance with OSHA, ASME B30.11, and ANSI MH27.1

3.04 MANUFACTURER'S SERVICES

A. Manufacturer's Representative: Present at Site or classroom designated by **[A: Owner,] [B: ,]** for minimum person-days listed below, travel time excluded:

1. 1 person-day for installation assistance and inspection.
2. 1 person-day for functional and performance testing and completion of Manufacturer's Certificate of Proper Installation.

B. See Section 01 43 33, Manufacturers' Field Services, and Section 01 91 14, Equipment Testing and Facility Startup.

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3.05 SUPPLEMENTS

A. The supplements listed below, following “End of Section,” are a part of this Specification.

1. Facility 300, Filters Monorail System:
   a. Hoist/Monorail Data Sheet, System No. 1.
   b. Hoist/Monorail Dimension Sheet, System No. 1.
   c. Induction Motor Data Sheet 1, System No. 1.
   d. Induction Motor Data Sheet 2, System No. 1.
2. Facility 300, Pipe Gallery Monorail System:
   a. Hoist/Monorail Data Sheet, System No. 2.
   b. Hoist/Monorail Dimension Sheet, System No. 2.
   c. Induction Motor Data Sheet, System No. 2.
   d. Induction Motor Data Sheet 2, System No. 2.
3. Facility 300, GAC Gallery Monorail System:
   a. Hoist/Monorail Data Sheet, System No. 3.
   b. Hoist/Monorail Dimension Sheet, System No. 3.
   c. Induction Motor Data Sheet, System No. 3.
   d. Induction Motor Data Sheet 2, System No. 3.

END OF SECTION

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HOIST/MONORAIL DATA SHEET
Filters Monorail System No. 1

Project: _____ Manufacturer.: _____

Owner: _____ Model No.: _____

Service: Filters Monorail System Number of Units: One

Equip. Tag Number(s): MRL-300-500-01 Rev/Date/By: ____/____/____

GENERAL REQUIREMENTS

Equipment Capacity: 3 tons

Method of Control: Pendent

Location of Control: Trolly

Equipment Location:

☒Indoors ☐Outdoors

Factory Testing:

☒Required ☐Not Required

Field Testing: ☐Not required

☒Required, functional and performance

Power Supply: _____

Voltage 460

Phase 3

Frequency 60 Hz

HOIST

Type:

☒Electric, Wire Rope ☐Hand Operated, Chain

Service Class (ANSI):

☐H1 (standby) ☐H2 (light) ☒H3 (standard)

☐H4 (heavy) ☐H5 (severe)

Speed (fpm): 0 to 22

☐Constant Speed ☐Two Speed ☒Variable Speed

Motor hp: 5

Hook: See Hoist/Monorail Dimension Sheet

Hook Manufacturer: _____

Reeving: Single

TROLLEY

Type:

☐Top Running ☒Underhung

Service Class (ANSI):

☐A1 (standby) ☐A2 (infrequent) ☒B (light)

☐C (moderate) ☐D (heavy)

Speed (fpm): 0 to 50

☐Constant Speed ☒Variable Speed ☐Hand Operated

Motor hp: 1/2

Electric Conductors:

☐Bus Bar ☒Festoon ☐ _____

☐Cable Reel

SPECIAL REQUIREMENTS

Accessories:

☐Central Lubrication System

☒OSHA operating and safety devices

Remote Controls:

☐Infrared, line-of-sight

☐Frequency modulated (FM)

Manufacturer: _____

☒Extended Grease Fittings

Special Electrical Requirements: _____

See Hoist/Monorail Dimension Sheet for clearances, lift distances, and details.

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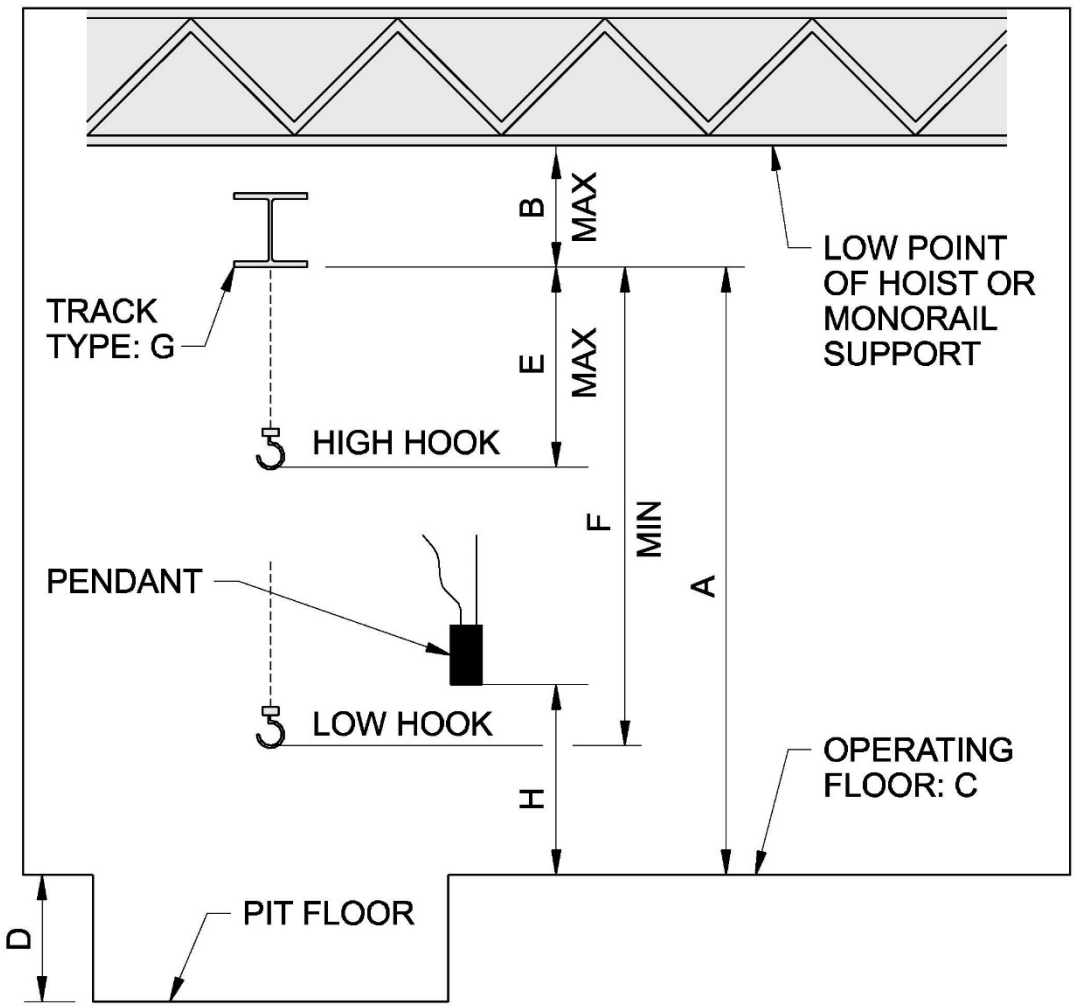
HOIST/MONORAIL DIMENSION SHEET
Filters Monorail System No. 1

Building Clearances

Project: _____

Owner: _____

Equipment Tag Number(s): MRL-300-500-01



A: 30’-0”
B: 1’-8”
C: 6644.7 ft elevation
D: 17’-0”
E: 2’-0”
F: 27’-0”
G: See Drawings for Location and Length
H: 2’-0”

Notes:

1. Monorail Track Length: 80’-0”

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INDUCTION MOTOR DATA SHEET

Project: _____

Owner: _____

Equipment Name: Filters Monorail System No. 1

Equipment Tag Number(s): MRL-300-500-01

Type: Squirrel-cage induction meeting requirements of NEMA MG 1

Manufacturer: For multiple units of the same type of equipment, furnish motors and accessories of a single manufacturer.

Hazardous Location: ☐ Furnish motors for hazardous (classified) locations that conform to UL 674 and have an applied UL listing mark.

Motor Horsepower: 5 hp

Voltage: 480 v

Phase: 3

Frequency: 60 Hz

Synchronous Speed: _____ rpm

☐ Thermal Protection: _____

☐ Space Heater: volts, single-phase

Guaranteed Minimum Efficiency at Full Load: _____ percent

Guaranteed Minimum Power Factor at Full Load: _____ percent

Service Factor (@ rated max. amb. temp.): ☐ 1.0 ☒ 1.15

Enclosure Type: _____

☐ Multispeed, Two-Speed: _____ / _____ rpm

Winding: ☐ One ☐ Two

Mounting Type: ☐ Horizontal ☐ Vertical

☐ Vertical Shaft: ☐ Solid ☐ Hollow

☐ Vertical Thrust Capacity (lb): Up _____ Down _____

☒ Adjustable Speed Drive: See Section 26 29 23, Low-Voltage Adjustable Frequency Drive System.

Operating Speed Range: _____ to _____% of Rated Speed

☐ Variable Torque

☐ Constant Torque

Additional Motor Requirements: ☒ See Section 26 20 00, Low Voltage AC Induction Motors.

Special Features:

_____

_____

_____

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INDUCTION MOTOR DATA SHEET

Project: _____

Owner: _____

Equipment Name: Filters Monorail System No. 1

Equipment Tag Number(s): MRL-300-500-01

Type: Squirrel-cage induction meeting requirements of NEMA MG 1

Manufacturer: For multiple units of the same type of equipment, furnish motors and accessories of a single manufacturer.

Hazardous Location: ☐ Furnish motors for hazardous (classified) locations that conform to UL 674 and have an applied UL listing mark.

Motor Horsepower: 0.5 hp

Voltage: 480 v

Phase: 3

Frequency: 60 Hz

Synchronous Speed: _____ rpm

☐ Thermal Protection: _____

☐ Space Heater: volts, single-phase

Guaranteed Minimum Efficiency at Full Load: _____ percent

Guaranteed Minimum Power Factor at Full Load: _____ percent

Service Factor (@ rated max. amb. temp.): ☐ 1.0 ☒ 1.15

Enclosure Type: _____

☐ Multispeed, Two-Speed: _____ / _____ rpm

Winding: ☐ One ☐ Two

Mounting Type: ☐ Horizontal ☐ Vertical

☐ Vertical Shaft: ☐ Solid ☐ Hollow

☐ Vertical Thrust Capacity (lb): Up _____ Down _____

☒ Adjustable Speed Drive: See Section 26 29 23, Low-Voltage Adjustable Frequency Drive System.

Operating Speed Range: _____ to _____% of Rated Speed

☐ Variable Torque

☐ Constant Torque

Additional Motor Requirements: ☒ See Section 26 20 00, Low Voltage AC Induction Motors.

Special Features:

_____

_____

_____

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HOIST/MONORAIL DATA SHEET
Pipe Gallery Monorail System No. 2

Project: _____ Manufacturer.: _____

Owner: _____ Model No.: _____

Service: Pipe Gallery Monorail System Number of Units: One

Equip. Tag Number(s): MRL-300-500-02 Rev/Date/By: ____/____/____

GENERAL REQUIREMENTS

Equipment Capacity: 3 tons

Method of Control: Pendent

Location of Control: Trolly

Equipment Location:

☒Indoors ☐Outdoors

Factory Testing:

☒Required ☐Not Required

Field Testing: ☐Not required

☒Required, functional and performance

Power Supply: _____

Voltage 460

Phase 3

Frequency 60 Hz

HOIST

Type:

☒Electric, Wire Rope ☐Hand Operated, Chain

Service Class (ANSI):

☐H1 (standby) ☐H2 (light) ☒H3 (standard)

☐H4 (heavy) ☐H5 (severe)

Speed (fpm): 0 to 22

☐Constant Speed ☐Two Speed ☒Variable Speed

Motor hp: 5

Hook: See Hoist/Monorail Dimension Sheet

Hook Manufacturer: _____

Reeving: Single

TROLLEY

Type:

☐Top Running ☒Underhung

Service Class (ANSI):

☐A1 (standby) ☐A2 (infrequent) ☒B (light)

☐C (moderate) ☐D (heavy)

Speed (fpm): 0 to 50

☐Constant Speed ☒Variable Speed ☐Hand Operated

Motor hp: 1/2

Electric Conductors:

☐Bus Bar ☒Festoon ☐ _____

☐Cable Reel

SPECIAL REQUIREMENTS

Accessories:

☐Central Lubrication System

☒OSHA operating and safety devices

Remote Controls:

☐Infrared, line-of-sight

☐Frequency modulated (FM)

Manufacturer: _____

☒Extended Grease Fittings

Special Electrical Requirements: _____

See Hoist/Monorail Dimension Sheet for clearances, lift distances, and details.

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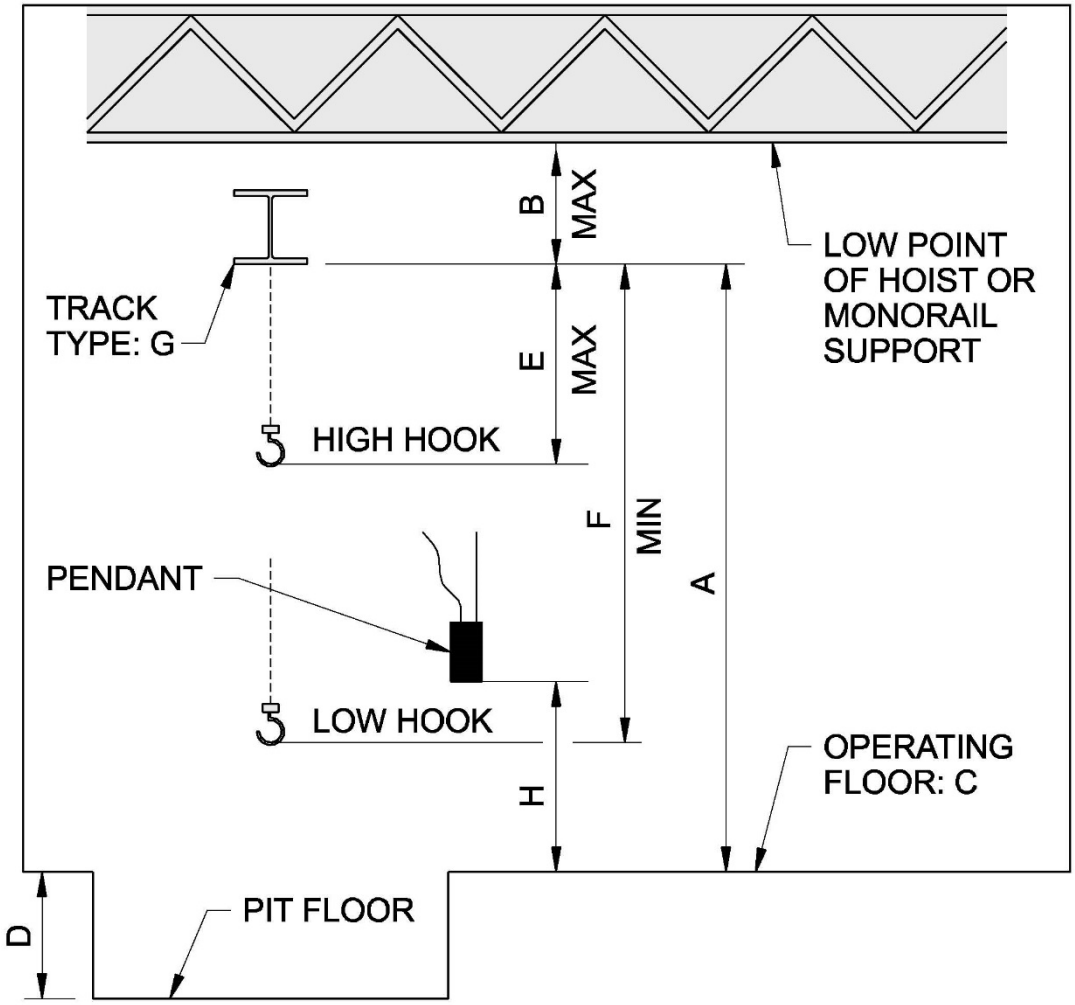
HOIST/MONORAIL DIMENSION SHEET
Pipe Gallery Monorail System No. 2

Building Clearances

Project: _____

Owner: _____

Equipment Tag Number(s): MRL-300-500-02



A: 30’-0”
B: 1’-8”
C: 6632.0 ft elevation
D: 17’-0”
E: 2’-0”
F: 27’-0”
G: See Drawings for Location and Length
H: 2’-0”

Notes:

1. Monorail Track Length: 16’-0”

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INDUCTION MOTOR DATA SHEET

Project: _____

Owner: _____

Equipment Name: Pipe Gallery Monorail System No. 2

Equipment Tag Number(s): MRL-300-500-02

Type: Squirrel-cage induction meeting requirements of NEMA MG 1

Manufacturer: For multiple units of the same type of equipment, furnish motors and accessories of a single manufacturer.

Hazardous Location: ☐ Furnish motors for hazardous (classified) locations that conform to UL 674 and have an applied UL listing mark.

Motor Horsepower: 5 hp

Voltage: 480 v

Phase: 3

Frequency: 60 Hz

Synchronous Speed: _____ rpm

☐ Thermal Protection: _____

☐ Space Heater: volts, single-phase

Guaranteed Minimum Efficiency at Full Load: _____ percent

Guaranteed Minimum Power Factor at Full Load: _____ percent

Service Factor (@ rated max. amb. temp.): ☐ 1.0 ☒ 1.15

Enclosure Type: _____

☐ Multispeed, Two-Speed: _____ / _____ rpm

Winding: ☐ One ☐ Two

Mounting Type: ☐ Horizontal ☐ Vertical

☐ Vertical Shaft: ☐ Solid ☐ Hollow

☐ Vertical Thrust Capacity (lb): Up _____ Down _____

☒ Adjustable Speed Drive: See Section 26 29 23, Low-Voltage Adjustable Frequency Drive System.

Operating Speed Range: _____ to _____% of Rated Speed

☐ Variable Torque

☐ Constant Torque

Additional Motor Requirements: ☒ See Section 26 20 00, Low Voltage AC Induction Motors.

Special Features:

_____

_____

_____

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INDUCTION MOTOR DATA SHEET

Project: _____

Owner: _____

Equipment Name: Pipe Gallery Monorail System No. 2

Equipment Tag Number(s): MRL-300-500-02

Type: Squirrel-cage induction meeting requirements of NEMA MG 1

Manufacturer: For multiple units of the same type of equipment, furnish motors and accessories of a single manufacturer.

Hazardous Location: ☐ Furnish motors for hazardous (classified) locations that conform to UL 674 and have an applied UL listing mark.

Motor Horsepower: 0.5 hp

Voltage: 480 v

Phase: 3

Frequency: 60 Hz

Synchronous Speed: _____ rpm

☐ Thermal Protection: _____

☐ Space Heater: volts, single-phase

Guaranteed Minimum Efficiency at Full Load: _____ percent

Guaranteed Minimum Power Factor at Full Load: _____ percent

Service Factor (@ rated max. amb. temp.): ☐ 1.0 ☒ 1.15

Enclosure Type: _____

☐ Multispeed, Two-Speed: _____ / _____ rpm

Winding: ☐ One ☐ Two

Mounting Type: ☐ Horizontal ☐ Vertical

☐ Vertical Shaft: ☐ Solid ☐ Hollow

☐ Vertical Thrust Capacity (lb): Up _____ Down _____

☒ Adjustable Speed Drive: See Section 26 29 23, Low-Voltage Adjustable Frequency Drive System.

Operating Speed Range: _____ to _____% of Rated Speed

☐ Variable Torque

☐ Constant Torque

Additional Motor Requirements: ☒ See Section 26 20 00, Low Voltage AC Induction Motors.

Special Features:

_____

_____

_____

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HOIST/MONORAIL DATA SHEET
GAC Gallery Monorail System No. 3

Project: _____ Manufacturer.: _____

Owner: _____ Model No.: _____

Service: GAC Gallery Monorail System Number of Units: One

Equip. Tag Number(s): MRL-300-500-03 Rev/Date/By: ____/____/____

GENERAL REQUIREMENTS

Equipment Capacity: 3 tons

Method of Control: Pendent

Location of Control: Trolly

Equipment Location:

☒Indoors ☐Outdoors

Factory Testing:

☒Required ☐Not Required

Field Testing: ☐Not required

☒Required, functional and performance

Power Supply: _____

Voltage 460

Phase 3

Frequency 60 Hz

HOIST

Type:

☒Electric, Wire Rope ☐Hand Operated, Chain

Service Class (ANSI):

☐H1 (standby) ☐H2 (light) ☒H3 (standard)

☐H4 (heavy) ☐H5 (severe)

Speed (fpm): 0 to 22

☐Constant Speed ☐Two Speed ☒Variable Speed

Motor hp: 5

Hook: See Hoist/Monorail Dimension Sheet

Hook Manufacturer: _____

Reeving: Single

TROLLEY

Type:

☐Top Running ☒Underhung

Service Class (ANSI):

☐A1 (standby) ☐A2 (infrequent) ☒B (light)

☐C (moderate) ☐D (heavy)

Speed (fpm): 0 to 50

☐Constant Speed ☒Variable Speed ☐Hand Operated

Motor hp: 1/2

Electric Conductors:

☐Bus Bar ☒Festoon ☐ _____

☐Cable Reel

SPECIAL REQUIREMENTS

Accessories:

☐Central Lubrication System

☒OSHA operating and safety devices

Remote Controls:

☐Infrared, line-of-sight

☐Frequency modulated (FM)

Manufacturer: _____

☒Extended Grease Fittings

Special Electrical Requirements: _____

See Hoist/Monorail Dimension Sheet for clearances, lift distances, and details.

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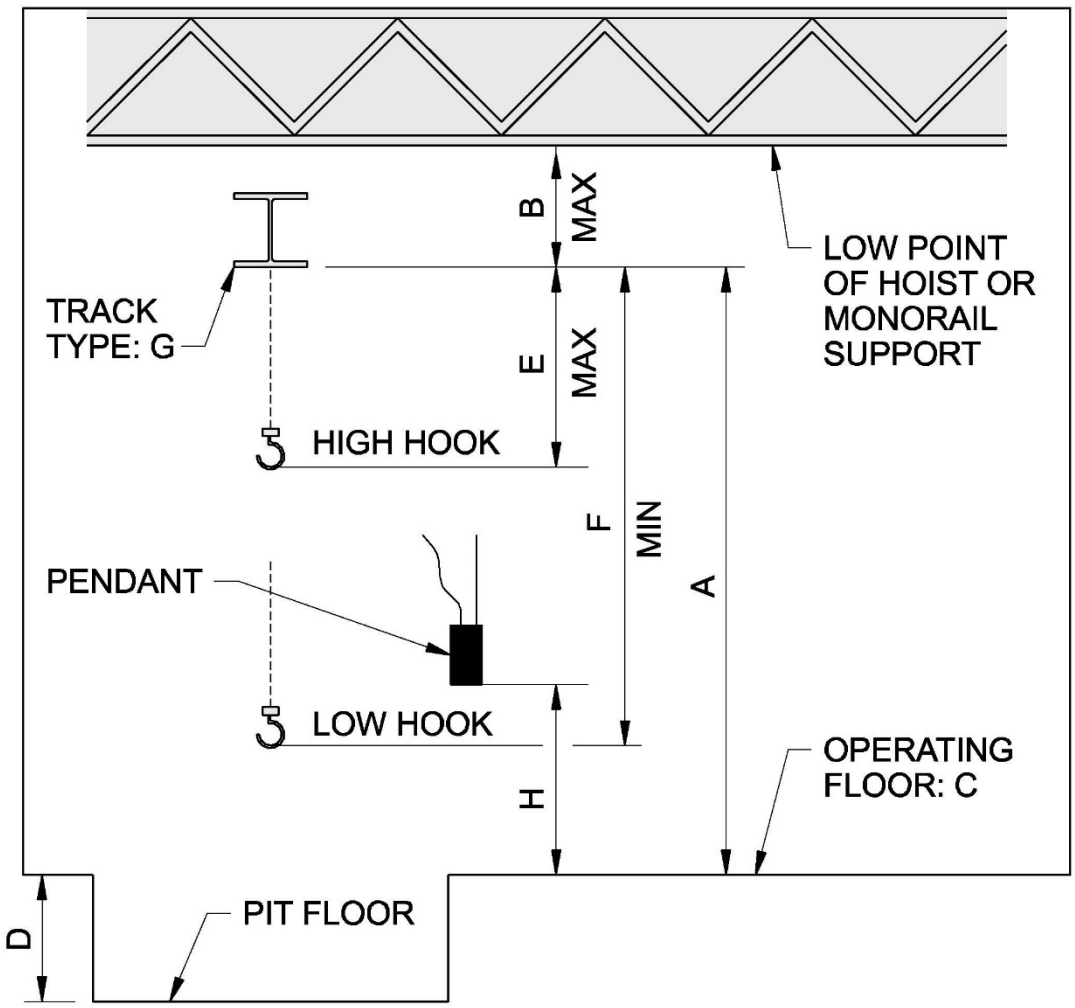
HOIST/MONORAIL DIMENSION SHEET
GAC Gallery Monorail System No. 3

Building Clearances

Project: _____

Owner: _____

Equipment Tag Number(s): MRL-300-500-03



A: 30’-0”
B: 1’-8”
C: 6632.0 ft elevation
D: 17’-0”
E: 2’-0”
F: 27’-0”
G: See Drawings for Location and Length
H: 2’-0”

Notes:

1. Monorail Track Length: 23’-0”

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INDUCTION MOTOR DATA SHEET

Project: _____

Owner: _____

Equipment Name: GAC Gallery Monorail System No. 3

Equipment Tag Number(s): MRL-300-500-03

Type: Squirrel-cage induction meeting requirements of NEMA MG 1

Manufacturer: For multiple units of the same type of equipment, furnish motors and accessories of a single manufacturer.

Hazardous Location: ☐ Furnish motors for hazardous (classified) locations that conform to UL 674 and have an applied UL listing mark.

Motor Horsepower: 5 hp

Voltage: 480 v

Phase: 3

Frequency: 60 Hz

Synchronous Speed: _____ rpm

☐ Thermal Protection: _____

☐ Space Heater: volts, single-phase

Guaranteed Minimum Efficiency at Full Load: _____ percent

Guaranteed Minimum Power Factor at Full Load: _____ percent

Service Factor (@ rated max. amb. temp.): ☐ 1.0 ☒ 1.15

Enclosure Type: _____

☐ Multispeed, Two-Speed: _____ / _____ rpm

Winding: ☐ One ☐ Two

Mounting Type: ☐ Horizontal ☐ Vertical

☐ Vertical Shaft: ☐ Solid ☐ Hollow

☐ Vertical Thrust Capacity (lb): Up _____ Down _____

☒ Adjustable Speed Drive: See Section 26 29 23, Low-Voltage Adjustable Frequency Drive System.

Operating Speed Range: _____ to _____% of Rated Speed

☐ Variable Torque

☐ Constant Torque

Additional Motor Requirements: ☒ See Section 26 20 00, Low Voltage AC Induction Motors.

Special Features:

_____

_____

_____

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INDUCTION MOTOR DATA SHEET

Project: _____

Owner: _____

Equipment Name: GAC Gallery Monorail System No. 3

Equipment Tag Number(s): MRL-300-500-03

Type: Squirrel-cage induction meeting requirements of NEMA MG 1

Manufacturer: For multiple units of the same type of equipment, furnish motors and accessories of a single manufacturer.

Hazardous Location: ☐ Furnish motors for hazardous (classified) locations that conform to UL 674 and have an applied UL listing mark.

Motor Horsepower: 0.5 hp

Voltage: 480 v

Phase: 3

Frequency: 60 Hz

Synchronous Speed: _____ rpm

☐ Thermal Protection: _____

☐ Space Heater: volts, single-phase

Guaranteed Minimum Efficiency at Full Load: _____ percent

Guaranteed Minimum Power Factor at Full Load: _____ percent

Service Factor (@ rated max. amb. temp.): ☐ 1.0 ☒ 1.15

Enclosure Type: _____

☐ Multispeed, Two-Speed: _____ / _____ rpm

Winding: ☐ One ☐ Two

Mounting Type: ☐ Horizontal ☐ Vertical

☐ Vertical Shaft: ☐ Solid ☐ Hollow

☐ Vertical Thrust Capacity (lb): Up _____ Down _____

☒ Adjustable Speed Drive: See Section 26 29 23, Low-Voltage Adjustable Frequency Drive System.

Operating Speed Range: _____ to _____% of Rated Speed

☐ Variable Torque

☐ Constant Torque

Additional Motor Requirements: ☒ See Section 26 20 00, Low Voltage AC Induction Motors.

Special Features:

_____

_____

_____

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SECTION 43 31 13.13
GRANULAR ACTIVATED CARBON (GAC) FILTER MEDIA

PART 1 GENERAL

1.01 SUMMARY

A. This specification describes the GAC products for use as filter media in biological filtration and filter-adsorbers. The GAC shall be capable of removing turbidity, color, tastes, odors and other organic contaminants from effluent from water pretreatment processes and shall be able to function in biological filters. The GAC shall be made from selected grades of bituminous coal capable of withstanding repeated backwash procedures without significant change in physical sizes and shall be suitable for terminal reactivation and re-use. Only coal-based GAC will be acceptable.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Water Works Association (AWWA):
   a. B100, Granular Filter Material.
   b. B604, Granular Activated Carbon (GAC).

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings: Submit manufacturer's product information not less than 30 days prior to shipment, including grain size ranges for the GAC media layer specified, total ash percent, and iodine number. Media sizes shall be in millimeters and include Effective Size and Uniformity Coefficient. Data on flow rate versus expansion of the media during fluidization backwashing at three different temperatures shall also be included.
2. Samples: Submit no less than 2-pound samples of GAC media following delivery of shipment, with a Certificate of Analysis which shall certify that sample shipped to the Site is from the same batch as that shipped to the Project Site, virgin carbon and in full compliance with the specifications noted in Article 2.02.

B. Informational Submittals:

1. Submit gradation test results of GAC media, including sieve analysis prior to loading and shipment.

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2. Submit data showing successful application of the GAC in municipal water treatment plants including turbidity and organic contaminant removal, along with references.

PART 2 PRODUCTS

2.01 MANUFACTURERS OF GRANULAR ACTIVATED CARBON

A. Calgon Carbon Corporation.

B. Norit Americas, Inc.

C. U.S. Filter Westates.

D. The manufacturer shall have a minimum of 10 years experience in supplying GAC to water treatment plants.

2.02 SPECIFICATIONS

A. The GAC shall be clean, hard, durable particles in conformance with AWWA B604, modified as follows:

1. Deliver GAC in bulk containers or bulk trailer.
2. The GAC shall be NSF Standard 61 certified virgin material manufactured from select grades of bituminous coal having the following properties:
    a. Particle Size Distribution: 8 by 30 carbon with maximum of 5 percent by weight larger than No. 8 mesh (2.36 mm) sieve and maximum of 4 percent by weight smaller than No. 30 mesh (0.60 mm) sieve.
    b. Granular activated carbon with effective size of 0.8 to 1.0 mm, Uniformity Coefficient of no greater than 2.1.
    c. Minimum abrasion number of 80 (80 percent as determined by either the stirring abrasion test or the Ro-Tap abrasion test).
    d. Minimum adsorptive capacity as measured by iodine number of 900 mg iodine/g carbon.
    e. Minimum surface area of 900 sq m/g.
    f. Maximum water soluble ash of 0.5 percent by weight.
    g. Maximum total ash content of 8 percent by weight.
    h. Maximum moisture as packed of 2.0 percent by weight.
    i. Real density of 2.1 g/cm^3.
    j. Apparent density, backwashed and drained of 0.46 to 0.65 g/cm^3.
    k. Particle density, wetted in water of 1.3 to 1.4 g/cm^3.
    l. Pore volume of 0.75 to 0.85 cm^3/g.
3. Depth: **[A:]** inches. See Drawings for filter dimensions.

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2.03 SOURCE QUALITY CONTROL

A. Owner will test samples in accordance with procedures specified in AWWA B100 and AWWA B604.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:

1. GAC depletes oxygen from air and can be hazardous in a confined situation. Contractor shall be responsible for worker's safety and follow all local, State, and Federal guidelines pertaining to confined space entry procedures. Obtain necessary permits for work in confined areas.
2. The GAC shall be installed as a wet slurry to minimize abrasion and dust.
3. Do not permit workers to walk or stand directly on media. Use boards that will sustain workers' weight without displacing media or gravel if specified.
4. Before GAC media is placed, mark top of GAC layer on side of filter.

B. GAC Media:

1. Transport and place media carefully to prevent contamination of any sort.
2. Any filter media which becomes contaminated or dirty (i.e., contains more than 0.5 percent of foreign material by weight), either before or after it has been placed in the filters, shall be removed and replaced with clean media.
3. Install as specified in the GAC adsorber vessel's O&M manual.
4. Final depth of GAC media after washing shall be the specified depth of **[A:]** inches.

3.02 TESTING

A. After GAC media placement is complete the filter bed shall be fluidized at a rate of 15 gpm/sf for approximately 10 minutes. After GAC has settled, Owner will take a full depth core sample within each filter bed using coring equipment. The cores will be dried and sieve analyzed to confirm gradation, effective size, and uniformity coefficient. Iodine number and total ash content will also be tested.

B. If GAC media does not meet specifications, Contractor shall replace some or all of the GAC until specifications are met.

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3.03 DISINFECTION

A. Prior to installation of GAC media the filter box shall be disinfected. See Section 33 13 00, Disinfecting of Water Utility Distribution.

3.04 MANUFACTURER'S SERVICES

A. A manufacturer's technical representative for the GAC media specified shall be present at the Job Site continuously during placement of media for installation supervision, inspection, and certification of the installation. The representative shall be a full-time, direct employee of the filter media supplier and shall have a minimum of 2 years experience during the past 5 years in filter media installation. Maximum time onsite, excluding travel, is 3 days.

B. Provide a manufacturer's certificate of proper installation in accordance with Division 1, General Requirements.

END OF SECTION

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SECTION 43 31 14
PRESSURE FILTER SYSTEM

PART 1 GENERAL

1.01 GENERAL

A. All items of equipment specified herein shall be furnished by one Supplier. This Supplier shall have the responsibility of providing the equipment, accessories, and installation supervision required to provide a fully functional filtration system.

B. Like items of equipment provided hereunder shall be the end products of one manufacturer in order to achieve standardization for appearance, operation, maintenance, spare parts, and Supplier's service.

1.02 EQUIPMENT

A. Note that where specific dimensions, mechanical or structural features, descriptions of mounting requirements, or basic equipment layout and configuration are listed in these Specifications**,** it shall be understood that this is for purposes of describing the base system only. It is not intended that all manufacturers of competing equipment be required to match the dimensions, geometry, or construction details precisely. Rather, features described will be used as a basis for determining equivalency of competing systems to the base system. Due to space limitations, the filter system supplier shall closely coordinate the design of the equipment with the Facility Layout Drawings included in the Contract Documents.

1.03 EQUIPMENT NUMBERS

A. TNK-300-105-00, GAC Adsorption Vessel 1.

B. TNK-300-106-00, GAC Adsorption Vessel 2.

1.04 SUBMITTALS

A. In accordance with Division 1, General Requirements.

B. References: The Supplier shall be experienced in the design and construction of pressure filters, and shall have built a minimum of ten comparable projects within the last 5 years. The Supplier shall provide references and documentation of the experience with dates, references, names and size of installations.

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C. Shop Drawings:

1. Drawings showing dimensions, weights, and details of components, piping connections, and wiring for installation and operation.
2. Double line piping drawings (piping schematics will not be acceptable) showing all piping, valves, and accessories furnished with the filters and interconnections with piping and services provided by others.
3. Calculations shall be provided to the DB Contractor demonstrating compliance with ASME Section VIII Pressure Vessel Code and shall be stamped by a Professional Engineer registered in the State of New Mexico.
4. Furnish standard operating procedures.
5. Product data for equipment, components, and accessories.
6. Documentation on the media retaining screens demonstrating minimum media loss during backwash

D. Quality Control Submittals:

1. Supplier's Certificate of Proper Installation for filter and accessories.
2. Supplier's written installation instructions.
3. Operation and maintenance manual.
4. Test Reports:
    a. Factory inspections.
    b. Factory tests and adjustments.
    c. Factory pressure test for the filter vessel actually provided.

E. Contract Closeout Submittals: Operation and maintenance manual and Supplier's warranty. Refer to Section 40 99 90, Package Control Systems, for additional Operations and Maintenance Manuals requirements related to I&C System.

1.05 MAINTENANCE

A. Extra Materials:

1. Equipment supplier shall provide spare parts sufficient for 2 years’ of operation.
2. Supplier shall provide a complete set of valve seats for the GAC Contactor System.
3. DB Contractor will furnish water and pretreatment chemicals necessary for performance testing.

1.06 WARRANTY

A. Provide per Contract Documents.

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PART 2 PRODUCTS

2.01 SUPPLIERS

A. Materials, equipment, and accessories specified in this section shall be products of (Manufacturer, Model Number):

1. Calgon Carbon, Model 10.
2. Or equal.

2.02 SERVICE CONDITIONS

A. Exposure: All equipment shall be installed inside a building maintained at 45 to 105 degrees F.

B. Water Quality:

1. Water Temperature: 0.5 to 30.0 degrees C.
2. Turbidity: Less than or equal to 0.05 NTU.
3. pH: 7.6 – 8.0.

2.03 PERFORMANCE AND DESIGN REQUIREMENTS

A. The filter system shall meet the design requirements presented in Table 1:

Table 1
Design Criteria Pressure Filter System

Item	Values	Units
Filter System Maximum Effluent Design Flow Rate	1.0	mgd
Maximum Design Filter Loading Rate (1 Filter in Standby)	9.0	gpm/sf
Number of Active Filters	1	--
Number of Standby Filters	1	--
Total Number of Filters	2	--
Maximum Design Filter Loading Rate (no Filters in Standby)	4.5	gpm/sf
Media Type & Effective Size (Refer to Section 43 31 13.13, Granular Activated Carbon Filter Media)	GAC	--
Media Depth		in
Individual Filter Area	78.5	sf
Vessel Diameter	10.0	feet

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Table 1 Design Criteria Pressure Filter System		
Item	**Values**	**Units**
Vessel Straight Side Height	12.0	feet
Backwash Rate	18.0	gpm/sf
Influent Pipe Diameter	8	in
Effluent Pipe Diameter	8	in
Backwash Waste Header Diameter	8	in
Design Working Pressure	125	psi
Maximum Piping Manifold, Internal Piping, and Underdrain Pressure Loss During Filtration at 9.0 gpm/sf		ft
Maximum Piping Manifold, Internal Piping, and Underdrain Pressure Loss During Backwash at 18.0.gpm/sf		ft
Maximum Media Losses	<= 5%	per year

B. Coatings and lining shall be approved and installed for use in potable water service.

C. Underdrain system shall provide a minimum headloss and evenly distribute backwash water.

2.04 EQUIPMENT DESCRIPTION

A. All equipment and accessories shall be provided as required for proper functioning systems including, but not limited to, the following:

1. The filter tanks shall be of welded steel construction using SA-516 Grade 70 steel, and shall be tested to a hydrostatic pressure 30 percent in excess of the designed working pressure in Table 1. The tanks shall be ASME code Section VIII construction with ASME stamp.
2. Each tank shall include the following features:
    a. One 20-inch circular manway.
    b. Flange pad or nozzle type connections to interface external piping.
        1) Four lifting lugs minimum.
        2) Four structural steel, vessel supports.
    c. Tank interior and exterior painting shall meet the requirements in Section 09 90 00, Painting and Coating.

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3. The shared piping manifold shall include the following features:
    a. Manifold shall conform to the design presented in the P&IDs.
    b. Piping manifold shall be centrally located between the vessels.
    c. Four dedicated 8-inch connections provided for following:
        1) Backwash waste (BWW) & Filter to Waste (FTW).
        2) GAC Influent (GI).
        3) GAC Effluent (GE).
        4) Backwash Supply (BWS).
    d. Piping manifold shall allow for parallel and duty-standby operation.
4. Filter Inlet Distributors:
    a. The shared piping manifold shall distribute GI.
    b. The inlet distributors shall be installed by the filter manufacturer prior to shipment.
5. Underdrain System:
    a. Alternate A:
        1) One 4-inch media removal pipe per cell installed just above the underdrain with a blind flange.
        2) The underdrain system shall consist of septa nozzles.
            a) Nozzle underdrain system shall conform to the performance requirements specified in Table 1.
            b) Location and quantity of nozzles to be designed by vessel manufacturer.
        3) The underdrain systems shall be installed by the filter supplier prior to shipment.
    b. Alternate B:
        1) Each vessel shall be furnished with a header lateral underdrain system designed to uniformly distribute backwash water and for the collection of filtered water. The distributor shall consist of manifold and laterals.
        2)
        3) Internal underdrain components shall be furnished and factory installed within the vessels by the filter manufacturer prior to shipment.
6. Filtration Media: The Supplier shall provide a system that is compliant with the media specified in Section 43 31 13.13, Granular Activated Carbon (GAC) Filter Media.
7. Filter Exterior Valving:
    a. Provide wafer style butterfly valves where possible and standard valves where required meeting the following requirements: Flanged valves shall have ANSI B16.1 Class 125-lb flanges. Valve bodies shall be cast iron or ductile iron. Shaft seals shall be designed for use with standard split-V type packing or other acceptable seal. The interior passage of butterfly valves shall not have any obstructions or stops, and in no case, shall be minimum port diameter of the valve be less than 1-3/4 inches smaller the

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nominal valve diameter. The disc shall be cast iron per ASTM A48, Class 40C or ductile iron per ASTM A536. The disc seating edge shall be Type 316 stainless steel. The disc shall be securely attached to the valve shaft using ASTM A564, Type 630, stainless steel torque screws or a tangential pin locked in place with a set screw. The valve seats shall be cast epoxy retained Buna-N mounted in the body for water service or mechanically retained by the use of clamping rings, segment screws, or hardware. Seats retained on the valve disc shall also be acceptable. When mechanically retained seat is used, all sectional retainer clamping ring and bolts shall be Type 316 stainless steel. Valve bearings shall be of phenolic, stainless steel backed PTFE, or Teflon lined fiberglass backed. All stainless steel parts shall be fabricated from Type 316 stainless steel. Cartridge-type seats that rely on a high coefficient of friction for retention shall not be acceptable. All bronze parts shall conform with ASTM B62 – Composition Bronze Ounce Metal Castings, containing not more than 5 percent of zinc or more than 2 percent of aluminum, have a tensile strength of 60,000 psi, a minimum yield strength of 40,000 psi, and an elongation of at least 10 percent in 2 inches. Acceptable Manufacturers: DeZurik Corporation, Henry Pratt Company, or equal.

b. The shared piping manifold shall be furnished with automatic valves consisting of the following:
    1) Automatic Valving: Furnish valves with electric motor operators with fully opened and fully closed limit switches. The operators shall be equipped with a LOCAL/OFF/REMOTE switch, an OPEN/STOP/CLOSE pushbutton, and OPEN/CLOSE indicating lights.
        (1) Ten 8-inch butterfly valves shall be provided on the piping manifold.
        (2) Valve configuration shall allow for the duty-standby or parallel operation of the GAC vessels.
        (3) Valve configuration shall conform to the P&ID schematic.

c. Manual Isolating Valves: Provide manually geared, chain type operators on manual valves that cannot be operated from floor level.
    1) Valves shall be furnished for the following:
        a) Tank common drain (3-inch).
    2) Pressure Relief Valves: Pressure relief valves, or equivalent rupture discs, for water service shall be rated for a minimum pressure of 150 psig, and shall be bronze body with stainless steel internals. Connections shall be female threaded inlet and outlet unless otherwise shown on the Drawings. Body

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shall be angle style unless otherwise shown on the Drawings. Relief adjustment range shall encompass the listed pressure relief setpoint. If a setpoint is not listed or to be determined by the equipment being protected, provide a relief adjustment range of 50 to 120 psig. Pressure relief adjustment shall be possible without removing the valve from the pipeline.

8. Filter System Piping:
    a. Water Piping:
        1) Supplier shall provide face and interconnecting piping for a complete and operable system as indicated on the Drawings.
        2) All filter face and interconnecting piping and fittings shall be cement lined ductile iron (CLDI) conforming to AWWA C151.
        3) All piping exterior surfaces shall be prepared and painted according to Section 09 90 00, Painting and Coating.
        4) Finish painting of the filter system piping is to be field applied by the DB Contractor.
    b. General Notes:
        1) All pipe supports for face and interconnecting piping shall be furnished by the DB Contractor.
        2) All system face and interconnecting piping shall be furnished with the required bolts, studs, nuts, and gaskets as follows:
            a) Bolts: ASTM A307, Grade B, plated carbon steel.
            b) Studs: ASTM A307, Grade B, plated carbon steel.
            c) Nuts: ASTM A563 plated steel heavy hex.
            d) Gaskets: Garlock No. 91 or equal, 1/8-inch thick.
9. System Accessories:
    a. Filter Pressure Equipment:
        1) Capacitance or piezoelectric based pressure transmitters for absolute, gauge, and differential pressure monitoring – Endress+Hauser Cerabar S (absolute and gauge) or Deltabar S (differential), or equal.
        2) Each pressure switch and gauge shall be furnished with copper supply tubing, Swagelock tube fittings, and manual isolating valves.
        3) Provide one differential pressure transmitter per filter.
        4) Provide one pressure indicator transmitter on the filter effluent header.
    b. Sampling cocks shall be provided so that representative water samples may be secured at the following points: Common Filter Influent, Individual Filter Effluent, Common Filter Effluent.

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2.05 ACCESSORIES

A. Equipment Identification Plates:

1. An engraved Gravoply laminated identification plate shall be securely mounted on the equipment in a readily visible location. The plate shall bear the 1/4-inch minimum identification number indicated in this Specification and/or as shown on the Drawings.
2. Lifting Lugs:
   a. Individual equipment and/or each field disassemble part over 100 pounds in weight shall be provided with lifting lugs for easy handling.
   b. Pipe, fittings, valves, and valve operators shall not require lifting lugs.
3. Anchor Bolts: Provide anchor bolts and anchor bolt design as required in Section 05 50 05, Anchorage of Equipment.

PART 3 EXECUTION

3.01 SOURCE QUALITY CONTROL

A. Factory Inspections:

1. Inspect control panel for required construction, electrical connection, and intended function.
2. Inspect welds on vessels to ASME.

B. Factory Tests and Adjustments:

1. Test the control panel actually furnished.
2. Hydrostatically pressure test filter pressure vessel per ASME Code.

3.02 INSTALLATION

A. Equipment shall be installed in accordance with Supplier's instructions.

3.03 PAINTING

A. Exposed metal surfaces of equipment and accessories specified herein shall be field or shop prepared and primed as specified herein. Interior surfaces of the filter vessels shall be epoxy coated by the Supplier. Finish coat shall be applied by Supplier.

B. Nonferrous and corrosion-resistant ferrous alloys such as copper, bronze, monel, aluminum, chromium plate, and stainless steel need not be coated at the Supplier's discretion subject to the DB Contractor's review.

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3.04 FIELD QUALITY CONTROL

A. The Supplier, assisted by the DB Contractor, shall conduct field tests as described below.

1. Functional Test: Prior to plant startup, all equipment shall be inspected for proper alignment, proper connection, and satisfactory performance.
2. Field Test: Confirm proper performance of controls and automatic valves.
3. Hydrostatically test filter vessels and related piping.
4. Performance Test: Complete testing to demonstrate compliance to performance criteria detailed in Table 1 of this specification.

3.05 SUPPLIER’S SERVICES

A. Furnish Supplier’s representative for the following services at job site or classroom, as designated by the DB Contractor.

1. Installation assistance and inspection.
2. Functional and performance testing and completion of Supplier's Certificate of Proper Installation.
3. Prestartup classroom or site training of Board's personnel.
4. PLC programming and troubleshooting assistance as needed. Supplier shall be personnel responsible for systems programming.

B. Furnish startup services and training of Board’s personnel at such times as requested by DB Contractor.

END OF SECTION

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SECTION 43 40 02
FIBERGLASS REINFORCED PLASTIC TANK

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Society of Mechanical Engineers (ASME):
   a. B16.5, Pipe Flanges and Flanged Fittings: NPS 1/2 through 24.
   b. RTP-1, Reinforced Thermoset Plastic Corrosion Resistant Equipment.
2. ASTM International (ASTM):
   a. C582, Standard Specification for Contact-Molded Reinforced Thermosetting Plastic (RTP) Laminates for Corrosion-Resistant Equipment.
   b. D2583, Standard Test Method for Indentation Hardness of Rigid Plastics by Means of a Barcol Impressor.
   c. D2584, Standard Test Method for Ignition Loss of Cured Reinforced Resins.
   d. D3299, Standard Specification for Filament-Wound Glass-Fiber-Reinforced Thermoset Resin Corrosion-Resistant Tanks.
   e. D4097, Standard Specification for Contact-Molded Glass-Fiber-Reinforced Thermoset Resin Chemical-Resistant Tanks.
   f. E84, Standard Test Method for Surface Burning Characteristics of Building Materials.
   g. E1067, Standard Practice for Acoustic Emission Examination of Fiberglass Reinforced Plastic Resin (FRP) Tanks/Vessels.
3. Occupational Safety and Health Act (OSHA): Part 1910.24, Subpart D, Walking-Working Surfaces.

1.02 DEFINITIONS

A. FRP: Fiberglass reinforced plastic.

1.03 DESIGN REQUIREMENTS

A. Design Loads: In accordance with Section 01 61 00, Common Product Requirements.

B. Tanks specified to be fabricated to ASME RTP-1 requirements shall be designed, fabricated, and code stamped. ASME RTP-1 shall be all inclusive for tanks so specified.

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C. Design tank, including resin selection (unless specified), wall thickness, methods and locations of support, and stiffener requirements. Design shall be prepared and sealed by designer meeting requirements of Article Quality Assurance.

1.04 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Fabricators catalog information, descriptive literature, specifications, and identification of materials of construction, including complete resin system information.
   b. Letter from resin manufacturer stating that selected resin is suitable for intended service.
   c. Detailed fabrication drawings.
   d. Tank data indicating equipment number, pressure rating, diameter, straight shell lengths, overall lengths, wall thickness, corrosion barrier thickness, and details of nozzle designs.
   e. Tank capacity chart indicating gallons for each inch of depth and cumulative total from bottom.
   f. Fabricator's detailed requirements for tank foundations.
   g. Recommended bolt torque for bolted FRP connections.
   h. Seismic anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Seismic Anchorage and Bracing.
2. Samples: Laminate sample representative of production quality of surface finish and visual imperfections.

B. Informational Submittals:

1. Complete design calculations for tanks, supports and appropriate accessories.
2. Seismic anchorage and bracing calculations as required by Section 01 88 15, Seismic Anchorage and Bracing.
3. Certification to ASME RTP-1.
4. Fabricator's Certificate of Compliance with fabrication requirements.
5. Qualifications of Fabricator's Quality Assurance Supervisor.
6. Copy of fabricator's Quality Assurance Program.
7. Quality Assurance Inspection:
   a. Qualifications of Independent FRP Quality Assurance Inspector.
   b. Initial QA Inspection Report.
   c. Certification of Factory Testing.
8. Certification tank baffle design, and access nozzles have been coordinated with actual equipment being furnished.

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9. Component and attachment testing seismic certificate of compliance as required by Section 01 45 33, Special Inspection Observation and Testing.
10. Special shipping, storage and protection, and handling instructions.
11. Fabricator's printed installation and tank support instructions.
12. Manufacturer's Certificate of Proper Installation in accordance with Section 01 43 33, Manufacturers' Field Services.
13. Qualifications of Acoustic Emission Testing Agency.

C. Contract Closeout Submittals: Service records for repairs performed during construction.

1.05 QUALITY ASSURANCE

A. Fabricator's Quality Assurance Supervisor: Minimum of **[A: 3] [B: 5]** years' experience in fabrication of fiberglass structures.

B. Designer: Registered professional engineer New Mexico.

C. Independent FRP Quality Assurance Inspector:

1. Minimum 5 years' experience as FRP inspector.
2. Representing a corporately and financially independent organization that can function as an unbiased inspection authority.
3. Professionally independent of manufacturers, suppliers, and installers of systems being inspected.

D. Acoustic Emission Testing Agency: Minimum 5 years' experience in acoustic emission testing of fiberglass structures.

1.06 DELIVERY, STORAGE, AND HANDLING

A. In accordance with Section 01 61 00, Common Product Requirements. In addition, prepare and protect tank for shipment as follows:

1. Mount tank on padded cradles if shipped horizontally or on a suitable skid if shipped vertically.
2. Protect flanged nozzles with wooden blinds bolted to flange and having a diameter of 2 inches greater than outside diameter of flange.
3. Provide either rigid plugs inside ends to prevent deflection or wooden boxes for unflanged components. Brace open end of tank with suitable stiffening member to prevent deflection.
4. Do not ship components or other pieces loose inside tank.
5. Load tank with at least 2 inches of clearance between tank (including fittings) and bulkheads, or bed of vehicle.
6. Regardless of mode of transportation, firmly fasten and pad components to prevent shifting of load or flexing of components while in transit.

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1.07 SEQUENCING AND SCHEDULING

A. Do not ship tank from factory until Engineer's review of Certification of Factory Testing is completed.

PART 2 PRODUCTS

2.01 SUPPLEMENTS

A. Some specific requirements relative to this section are attached as supplements at the end of section.

2.02 SERVICE CONDITIONS

A. Operating Pressure: Atmospheric.

2.03 MATERIALS

A. Filament-Wound **[A: Contact-Molded]**: Fabricate in accordance with **[B: ASTM D3299, Type [C: I] [D: II]**, **Grade [E: 1] [F: 2]] [G: or] [H: and] [I: ASTM D4097, Grade [J: 1] [K: 2] [L: ASME RTP-1]**.

B. Resin:

1. Suitable for intended service.
2. Premium grade and corrosion resistant, such as chlorendic polyester, vinyl ester, or bisphenol A fumarate polyester.
3. Use same resin throughout entire tank shell.
4. Add ultraviolet absorbers to surfacing resin to improve weather resistance.
5. No dyes, pigments, or colorants, except in exterior gel coat.
6. No fillers or thixotropic agents.
7. Additives may be added to achieve fire retardancy. The Flame-Spread Rating of finish laminate shall be less than **[A: 25] [B:]**, as determined by ASTM E84. Additives shall not be added to interior layer, unless specifically required.
8. Curing System:
   a. As recommended by resin manufacturer or as specified herein.
   b. Cure products as specified in **[C: ASTM D3299] [D: and] [E: or] [F: ASTM D4097] [G: ASME RTP-1]**.
   c. Measure Barcol hardness according to ASTM D2583.
9. Post-cure tank and appurtenances in accordance with resin manufacturer's recommendation for time and temperature. Post-curing should be completed with warm-to-hot dry air, free of combustion products. Hot spots shall be avoided.

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10. For hypochlorite service, no MEKP cobalt catalyst system shall be allowed in liner. Cure liner with benzoyl peroxide-dimethyl aniline. Structural layer may be cured with either catalyst system.

C. Reinforcements:

1. Surfacing Veil: Chemical surfacing mat, **[A: Type C (chemical) glass, 10 mils thick,] [B: two layers of polyester fabric, 12 mils to 16 mils thick,]** with a finish and a binder compatible with the lay-up resin.
2. Other Reinforcements: In accordance with **[C: ASTM D3299] [D: ASTM D4097] [E: ASME RTP-1]**.

D. Laminate:

1. Consists of inner surface (corrosion barrier), interior layer, and exterior layer (structural layer).
2. Meet visual acceptance criteria in **[A: ASTM C582] [B: ASME RTP-1]**.
3. Meet requirements of mechanical properties in **[C: ASTM D3299] [D: ASTM D4097] [E: ASME RTP-1]**.
4. Reinforce inner surface with resin-rich surfacing veil as specified herein.
5. Apply a **[F:]** color coat after inspection of laminate has been completed.

E. Marking:

1. Identify each tank with fabricator's name, capacity in gallons, maximum temperature, design pressure/vacuum, specific gravity, pH, resin, minimum thickness, tank number, tank name, and date of manufacture.
2. Provide permanent marking. Seal decals, labels, etc., into laminate exterior with clear resin.
3. Calibration Strips:
   a. Translucent, 6 inches wide.
   b. Calibration: Multiples of 100 gallons or less.
   c. Stencil gallonage in 2-inch-high numerals.

F. Nozzles:

1. Gusset 4-inch or smaller nozzles with conical or plate type gussets. Larger nozzles shall be gusseted, if noted.
2. Finish flush with inside surface of tank, unless otherwise indicated.
3. Gaskets:
   a. Provide two per nozzle, 1/8-inch-thick, full-face elastomeric material having a hardness of Shore A60 plus or minus 5.
   b. Material shall be suitable for intended service.

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4. Flanged Nozzles: Rated at 100 psi, with other dimensions and bolting corresponding to ASME B16.5 for 150-pound steel flanges.
5. Back face of flanges shall be spot-faced, flat and parallel to flange face of sufficient diameter to accept SAE metal washer under bolthead or nut.

G. Dip-Pipes:

1. Provide inside and outside surfaces of dip-pipes with corrosion barrier.
2. Surfacing veil for this corrosion barrier shall be same as specified for tank.
3. Corrosion barrier shall consist of appropriate surfacing veil, backed by two layers of fiberglass mat.
4. If "ready-made" pipe is used, it shall have an equivalent internal corrosion barrier and shall have specified corrosion barrier applied to outside surface.

2.04 APPURTENANCES

A. Sight Glass (Type 1):

1. Tubular type PVC with **[A:]**-inch flanged connection.
2. Furnish with valves, drain cock, Pyrex glass, and stainless steel guard rods.
3. Parts coming in contact with liquid shall be either PVC or glass.
4. Calibrate tank in 100-gallon increments and paint calibrations adjacent to level tube with graduations and boldface figures.
5. Manufacturer and Product: Ernst Flow Industries; Model EFI-PVC.

B. Sight Glass (Type 2):

1. Calibrate in 100-gallon increments.
2. Abrasion and corrosion resistant.
3. Mount using 1/2-inch Tygon tubing, PVC fittings, PVC isolation ball valve, and stainless steel hose clamps.

C. Supports:

1. Pipe Supports:
   a. Provide for tank overflow pipes, loading pipes and recirculation pipes.
   b. Spacing of supports shall be as recommended by fabricator, but shall not be greater than 4 feet on center.
   c. As shown on Drawings, shall allow removal of pipe.
   d. **[A: FRP] [B: Type 316 stainless steel] [C:]** complete with necessary bolts, nuts, and washers.

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2. Level Probe Supports: **[D: FRP] [E: or] [F: stainless steel]**.
    a. Use mixer support design and location criteria obtained from mixer manufacturer for design, fabrication, and drilling mounting holes in channels and mixer support height.
    b. Fabricate with baffles recommended by mixer manufacturer.
    c. Minimum Support System:
        1) Two **[H: Type 304 stainless steel] [I: FRP] [J:]** channels for each mixer with adequate cross bracing and foot platform for mounting mixer directly on channels.
        2) Size support channels for dead and live loads imposed by mixer channels and grating, plus 150 psf live load on grating. **[K: Minimum size: _____.]**
        3) Support mixer without vibration.
        4) **[L: Include fiberglass grating, as specified in Section 06 82 00, Glass-Fiber Reinforced Plastic, with adequate supports to span between channels on both sides of mixer.]**

D. Platforms, Ladders, Handrails, and Kickplates:

1. Material: **[D: Stainless steel]** as specified in Section **[G: 05 52 19, Steel Railings]**.
2. Fasteners: **[J: Type 316 stainless steel.] [K: FRP.] [L:]**
3. Supports, **[M: FRP] [N:]**: Locate as required for field installation of ladders, platforms, or handrails.
4. For tanks under roof or canopy, provide overhead clearance in accordance with OSHA 1910.24.

E. Lifting Lugs: Provide suitably attached for tank weighing over 100 pounds.

F. Anchor Bolts: Type 316 stainless steel bolts, **[A: sized by fabricator, and [B: 1/2] [C:]-inch minimum diameter] [D: as shown on Drawings]** and as specified in Section 05 50 00, Metal Fabrications.

G. Manway Bolts: Type 316 stainless steel bolts and nuts as specified in Section 05 50 00, Metal Fabrications.

H. Tank Insulation and Heat Tracing: In accordance with Section 40 05 33, Heat Tracing.

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2.05 SOURCE QUALITY CONTROL

A. Independent FRP Inspector:

1. To be present at point of manufacture at time fabrication is started, to perform the following:
    a. Observe manufacturing methods, machinery, and techniques to ensure compliance with industry standards and these Specifications.
    b. Observe initial fabrication to verify compliance with these Specifications.
    c. Observe quality control methods for mixing resins and testing of completed equipment.
    d. Generally observe quality of other ongoing fabrication.
    e. Prepare Initial QA Inspection Report.
2. To be present at point of manufacture, upon completion of fabrication and prior to shipment, to perform or witness the following:
    a. Visual inspection to requirements of **[A: ASTM C582] [B: UBRS for ASME RTP-1]**.
    b. Barcol Hardness measurements per ASTM D2583.
    c. Acetone sensitivity test for internal secondary bonds.
    d. Glass content by ignition loss on three cutouts per ASTM D2584.
    e. Hydrostatic Leak Test:
        1) Perform on each tank.
        2) Fill to top nozzle; allow to stand for 2 hours with no visible leakage.
3. Prior to beginning repair work, repairs deemed acceptable by Independent FRP Inspector shall be approved by Engineer.

B. Identify and retain cutouts. Engineer may select certain cutouts for testing for physical properties of laminate.

C. **[A: Acoustic Emission Test:**

1. **Provide services of acoustic emission test agency to conduct test.**
2. **Test completed tank in accordance with ASTM E1067.]**

D. Factory Test Reports:

1. Certify results, by signature, of the following:
    a. Inspections.
    b. Results of hydrostatic testing.
    c. Test reports of physical properties of standard laminates.
    d. **[A: Test results and report for acoustic emission test.]**

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PART 3 EXECUTION

3.01 INSTALLATION

A. In accordance with fabricator's written instructions.

B. Accurately place anchor bolts using templates furnished by fabricator, and as specified in Section 05 50 00, Metal Fabrications.

3.02 FIELD QUALITY CONTROL

A. Functional Test:

1. Conduct on each tank.
2. Hydrostatic leak test with tank full of clean water. Allow water to stand for 24 hours to verify no leakage.

3.03 MANUFACTURER'S FIELD SERVICES

A. Provide fabricator's representative at Site **[A: in accordance with Section 01 43 33, Manufacturers' Field Services, and Section 01 91 14, Equipment Testing and Facility Startup]** for installation assistance, inspection and certification of proper installation **[B: and startup assistance]** for specified component, subsystem, equipment, or system.

3.04 SUPPLEMENTS

A. The supplements listed below, following "End of Section," are part of this specification.

1. FRP Tank Schedule.
2. Tank Data Sheet.
3. User's Basic Requirements Specification (UBRS) Form.

END OF SECTION

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FRP Tank Schedule			
Name of Tank*	Ferric Chloride Storage Tank	Sodium Hydroxide Storage Tank	Sodium Hypochlorite Storage Tank
Equipment Numbers	TNK38020001	TNK38040001	TNK38030001
Filament-wound or Contact-molded	Filament-wound	Filament-wound	Filament-wound
Maximum Capacity Measured to High Solution Level (gallons)	6,854 / 8,225 total volume	7,701 / 9,242 total volume	6,854 / 8,225 total volume
Installation (Vertical/Horizontal)	Vertical	Vertical	Vertical
Diameter (feet)	10.0	11.0	10.0
Straight Shell Height (feet)	14.0	13.0	14.0
Support (saddles, flat pad, legs)	Flat pad	Flat pad	Flat pad
Type of Bottom Head	Sloped	Sloped	Sloped
Type of Top Head			
Ladder Required (Yes/No)	Yes	Yes	
Tank Location (indoor/outdoor)	outdoor	indoor	indoor
Ambient Temperature Range (degrees F)	-10.5 to 104.6	-10.5 to 104.6	-10.5 to 104.6
Exterior Loading (psf):			
Personnel Roof Loads			
Platforms	NA	NA	NA
Mixers	NA	NA	NA
Pipe Supports	Yes	Yes	Yes
Operating Contents:			
Temperature (degrees F, not to exceed 180)	70	70	70
Chemical Composition	$FeCl_3$	NaOH	Cl_2
Specific Gravity	1.43	1.54	1.21
Concentration	37%	50%	10%
pH Range	<2	10-12	10-12
Sight Glass Type (1 or 2)			
Sight Glass Tube Length			
Insulation/Heat Tracing (Yes/No)	YES	NO	NO
*Specify feed/mix tanks as such.			

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TANK DATA SHEET

DATE _____

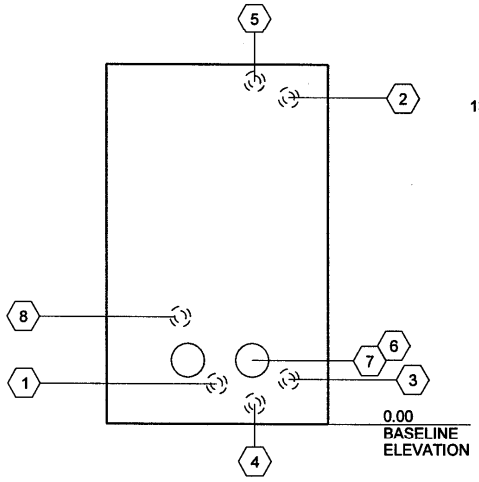
BY _____

PROJECT NUMBER _____

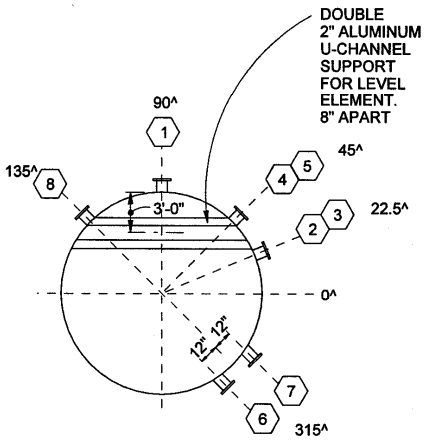
PROJECT _____

SERVICE SPENT CLEANING SOLUTION TANK

SIZE: 10'-6" DIAMETER BY 12'-0" shell HEIGHT CAPACITY 6,500 gallons (nominal)



COMPOSITE SECTION



PLAN

NOZZLES	MARK	NO.	SIZE	
OUTLET	1	1	3"	
LEVEL SWITCH	2	1	2" NPT	
LEVEL SWITCH	3	1	2" NPT	
DRAIN	4	1	4"	
OVERFLOW	5	1	4"	
HEATER	6	1	10"	
HEATER	7	1	10"	
TEMP SWITCH	8	1	3"	

DESIGN DATA			
TANK MATERIAL	FRP	GASKET MATERIAL	N/A
TEMPERATURE	60 UP TO 105	SPECIFIC GRAVITY	1 UP TO 1.02
CONTENTS	CLEANING SOLUTIONS		
EXTERIOR ENVIRONMENT	INDOORS		
TYPE OF COVER	OPEN		
REMARKS:	NOZZLES 6 AND 7 ARE PARALLEL TO		
	EACH OTHER 12" OFF TANK CL EACH WAY		
	PROVIDE TOP WITH ACCESS HATCH ON TOP		
	OF TANK FOR CHEMICAL LOADING		

EQUIPMENT NUMBER

T-7-7

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EB0000072 AAC001992

TANK DATA SHEET
T-7-7

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USER'S BASIC REQUIREMENTS SPECIFICATION (UBRS)
As Required by the Provisions of ASME RTP-1

RTP Edition No. _____

UBRS Revision No. _____

User Firm Name: _____

User's Agent Firm Name: _____

Title of Equipment: _____

User's Designation No.: _____

Installation Location (Name and Address): _____

_____

_____

UBRS Prepared by (User or User's Agent):

Name: _____ Phone No.: _____ Date: _____

Address: _____

_____

_____

1. Equipment Description (equipment sketch and nozzle schedule must be attached):

_____

_____

2. Additional Fabricator Responsibilities:

☐ Special Requirements:

☐ Acoustic Emission Testing

☐ Inspection or Testing Requirements not Listed in the Standard _____

_____

_____

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☐ _____

☐ _____

☐ User Waives Visual Inspection Prior to Application of Final Exterior Coat:

☐ Yes ☐ No

☐ Visual Inspection Acceptance Level (refer to Table 6-1 of ASME RTP-1):

☐ Level 1

☐ Level 2

Quantity Limitations for Gaseous Air Bubbles or Blisters:_____

_____

☐ Additional Inspection Aids/Methods (refer to Para. 6-940(c) of ASME RTP-1):

_____

_____

_____

3. Material Selection:

3.1 Material Selection by:

☐ Resin Manufacturer (include data per Section 4 of this Document)

☐ Fabricator (include data per Section 4 of this Document)

☐ End User. Applicable User's Specifications/Standards, Codes, Ordinances, FDA Requirements, etc. (list and specify; attach copies of local code/ordinance requirements):_____

☐ Other _____

3.2 Material of Construction:

Resin: _____ Catalyst/Cure System: _____

Veil: _____ Barcol Hardness per Para. 6-910(b)(4): _____

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☐ Lift Lugs: ☐ RTP ☐ Carbon Steel ☐ Other:_____

☐ Hold-down Lugs: ☐ RTP ☐ Carbon Steel ☐ Other:_____

4. Chemical Service Data (must be provided when Fabricator or resin manufacturer is making material selection):_____

4.1 Description of Process Function and Process Sequence:_____

_____

_____

_____

4.2 Contents:

	Concentration		
Chemical Name	Max. %	Min. %	Exposure Time
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

4.3 pH Range: ___ Max. _____ Min.

5. Design:

5.1 Design Conditions:

	Operating	Design
Internal Pressure	_____	_____
External Pressure	_____	_____
Temperature	_____	_____
Specific Gravity	_____	_____
Liquid Level	_____	_____

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Wind/Seismic/Snow Code (include edition or year) _____

Basic Wind Speed: _____ mph Classification Category _____

Exposure _____

Elevation Above Grade _____ ft Topographic Factors:_____

Seismic Zone _____ Site-specific Seismic Information (soil type, ground motion coefficients, etc.)____

Snow Load: _____ psf

Capacities: Operating _____ gal

Flooded _____ gal

5.2 Mechanical Agitator: ☐ Required ☐ Not Required

Dead Load _____ lb

Static Bending Moment _____ ft-lb

Dynamic Bending Moment _____ ft-lb

Torque _____ ft-lb

Horsepower _____ hp

Impeller Speed _____ rpm

Impeller Diameter _____ in

Number of Impellers _____

Foot Bearing: ☐ Yes ☐ No

5.3 Heating and Cooling:

☐ Electric Panels

☐ Steam Coil

☐ Steam Sparger

☐ Heat Exchanger

☐ Other _____

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5.4 Mechanical and Other Forces:

☐ Violent Chemical Reaction

☐ Subsurface Introduction of Gas and Vapor

☐ Subsurface Introduction of Steam

☐ Transmitted Mechanical Load/Force

☐ Impact Due to Introduction of Solids

☐ Vacuum from Pump Down (or Vessel Draining)

☐ Vacuum from Cool Down

☐ Other _____

5.5 Corrosion Barrier Excluded from Structural Calculations:

☐ Yes

☐ No

5.6 Declaration of Critical Service (only by User or User's Agent; refer to Para. 1-210 of ASME RTP-1):

☐ Yes

☐ No

6. Designation of Inspection (Reviewer Paras. 1-400, 1-430, and 1-440 of ASME RTP-1. It must be recognized that ASME RTP-1 establishes numerous duties for the Inspector, which necessitates that the Inspector be present in the fabrication shop throughout a major portion of the fabrication interval.) Inspector shall be:

☐ Fabricator's Quality Control Principal

☐ User's Representative

☐ Other _____

Inspector's Name: _____ Telephone: _____

Company: _____

Address: _____

_____

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6.1 Approval of Inspector Designation:

6.1.1 Authorized User's Representative:

Name _____ Title _____

Signature _____ Date _____

6.1.2 Authorized Fabricator's Representative:

Name _____ Title _____

Signature _____ Date _____

Additional Requirements: _____

_____

_____

_____

_____

_____

_____

_____

_____

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SECTION 44 42 19.04
ROTARY POSITIVE DISPLACEMENT BLOWER

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Gear Manufacturers Association (AGMA).
2. American National Standards Institute (ANSI).
3. ASTM International (ASTM):
   a. A48/A48M, Standard Specification for Gray Iron Castings.
   b. A395/A395M, Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures.
4. National Electrical Manufacturers Association (NEMA).
5. American Society of Heating, Refrigerating, and Air-conditioning Engineers:
   a. 52.2-2012.

1.02 DEFINITIONS

A. Absolute Discharge Pressure: Pressure in pounds per square inch absolute (psia) at the blower discharge flange in relation to Job Site barometric pressure.

B. BHP: (Shaft) brake horsepower is the standard curve horsepower required corrected for pressure, temperature and relative humidity at inlet conditions.

C. Discharge Pressure: Pressure in pounds per square inch gauge (psig) at the blower discharge flange at rated capacity.

D. Inlet Cubic Feet per Minute (ICFM): Volumetric rate of air at the inlet flange of the blower corrected to absolute pressure, temperature, and relative humidity. The pressure takes into account the inlet piping in filter pressure drops.

E. Pressure Rise: Pressure developed within the blower between the inlet and outlet flanges. It is the discharge pressure less the inlet pressure measured at the discharge and inlet flanges, respectively.

F. Standard Cubic Feet per Minute (SCFM): Volumetric rate of air measured in standard cubic feet per minute at 68 degrees F, pressure of 14.7 psig, and relative humidity of 36 percent.

G. SCADA: Supervisory Control and Data Acquisition.

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1.03 SYSTEM DESCRIPTION

A. Blower system, featuring rotary positive displacement blowers to supply air for the filter backwash process system.

B. Provide blower system, including, but not limited to, blowers, control panel, motors, drives, guards, drive couplings, baseplates, vibration isolators, supports, inlet silencers, discharge silencers, bypass silencers, relief valves, flexible connectors, noise enclosures, spare parts, outside air filter, and miscellaneous appurtenances as necessary.

1.04 DESIGN REQUIREMENTS

A. Design equipment with due regard to safety of operation, accessibility, and durability of parts, and complying with applicable OSHA, state, and local safety regulations.

B. Seismic Requirements: In accordance with Section 01 61 00, Common Product Requirements.

C. Each blower will receive room air from a dedicated filter and discharge into a main air discharge header.

D. Intermittent operation in an indoor environment.

E. Each blower shall start no more than two times per hour when operating in intermittent service.

F. Blowers shall meet rated performance and sound level when operating at a maximum gear speed of 3,985 rotations per minute. Operating speed shall not exceed 90 percent of rated speed.

G. Maximum Sound Pressure Level: 90 dBA, factory calculated, with inlet and discharge silencers, measured with a sound enclosure.

H. Performance Requirements:

Design Conditions	
Design Capacity, scfm	300
Maximum Capacity, icfm	432
Altitude, ft	6650
Barometric pressure, psia	11.6
Inlet air temperature, degrees F (Guarantee Point)	85

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Design Conditions	
Inlet air temperature range, degrees F	55 min to 85 max
Relative humidity, % (Guarantee Point)	60
Maximum inlet pressure loss, psid	0.95
Maximum discharge pressure loss, psid	0.16
Blower discharge pressure required, psid	10
Pressure relief valve setting, psig	11
Shaft brake horsepower, BHP[1,2]	30

[1]Includes main oil pump, if specified, and all gear and bearing frictional losses.

[2]Not to exceed motor nameplate horsepower at 1.0 service factor at the inlet air temperatures, pressure relief valve setting and altitude listed above.

1.05 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Complete list of system components to be provided.
   b. Make, model, weight, and horsepower of each equipment assembly.
   c. Complete catalog information, descriptive literature, specifications, and identification of materials of construction.
   d. Standard and specialized equipment assembly cuts.
   e. System layout, installation, and placing drawings for equipment, drivers, and bases.
   f. Performance data for each type of equipment that will show compliance with specification requirements stated herein.
   g. Horsepower demand over the operating range of the blower.
   h. Detailed structural, mechanical, and electrical drawings showing the equipment fabrications and interface with other items. Include dimensions, size, and locations of connections to other work.
   i. Motor: See requirements of Section 26 20 00, Low-Voltage AC Induction Motors.
   j. Monitoring System:
      1) Catalog cuts of each blower control system component, including monitoring panel components.

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2) Wiring diagrams, including baseplate-mounted terminal junction box and equipment monitoring panel.
3) Panel construction and face layout drawings.

k. Seismic anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.

l. Sound Enclosure:
1) Complete description of sound enclosure and accessories.
2) Calculated noise attenuation.

2. Samples: Color samples for finish coating. If paint manufacturer of finish coat differs from manufacturer of prime coat, provide both manufacturers' written confirmation that materials are compatible.

B. Informational Submittals:

1. Seismic anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements.
3. Factory calculated sound levels (dBA) of blower unit and silencers.
4. Factory calculated sound levels (dBA) of blower unit with silencers and sound enclosure.
5. Identification of outside utility requirements for each component such as air, water, power, etc. Include operating parameters for required utilities.
6. Pipe stress analysis for blower discharge piping when proposed piping requires modification to accommodate supplied equipment.
7. Special shipping, storage and protection, and handling instructions.
8. Manufacturer's written installation instructions.
9. List of special tools, materials, and supplies furnished with equipment for use prior to and during startup and for future maintenance.
10. Suggested spare parts list to maintain the equipment in service for a period of 5 years. Include a list of special tools required for checking, testing, parts replacement, and maintenance with current price information.
11. Routine maintenance requirements prior to plant startup.
12. Test Reports:
    a. Factory test reports for blower and motor.
    b. Field test procedures.
13. Operation and Maintenance Data as specified in Section 01 78 23, Operation and Maintenance Data.
14. Manufacturer's Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers' Field Services.

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1.06 EXTRA MATERIALS

A. Furnish, tag, and box for shipment and storage the following spare parts, special tools (if required), and materials:

Item	Quantity
Inlet Filters	Enough for two complete changes per unit
Flexible Coupling	One complete set
Drive V-Belts	One complete set
If required, special tools required to maintain or dismantle	One complete set

B. Delivery: In accordance with Section 01 61 00, Common Product Requirements.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. General:

1. Where possible, provide end products of one manufacturer in order to achieve standardization for appearance, operation, maintenance, replacement, and manufacturer's service.
2. Manufacture spare parts to United States standard sizes and gauges.

B. Materials, equipment, and accessories specified in this section shall be products of:

1. Kaeser Compressors, Inc. (Model: DB 166C).
2. Aerzen USA.
3. Gardner Denver.

2.02 COMPONENTS

A. Blower:

1. Rotary positive displacement type, belt driven by horizontal electric motor.
2. Casing: One-piece construction, ASTM A48/A48M, Class 30B close-grain cast iron strongly ribbed to prevent distortion at the specified operating conditions. Separate headplates of cast iron.

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3. Bearings:
    a. Each shaft assembly shall be supported by single-row roller bearings sized for a minimum L10 rating of 100,000 hours at design conditions.
    b. Drive end bearings shall be fixed to control axial location of impeller assembly.
    c. Bearings and gears shall be lubricated by a splash type lubrication system on both ends of the rotors.
    d. Provide each bearing with a positive lip type oil seal designed to prevent lubricant from entering air stream and a labyrinth seal on each shaft designed to reduce air leakage at point where shaft extends through headplate of blower casing.
    e. Make further provision to vent area between the two sealing systems to atmosphere to relieve excessive pressure on seals.
4. Rotors:
    a. Each rotor/shaft assembly integrally cast from high-strength ASTM A395/A395M Type 60-45-15 ductile iron with a minimum tensile strength of 60,000 pounds per square inch.
    b. Three-lobe rotor type, rotating in opposite directions in a common casing without rubbing, liquid seals, or lubrication.
    c. Positioned by timing gears to maintain proper clearances.
5. Shafts:
    a. Cast iron, integral with rotors.
    b. Machine labyrinth seals into shaft to minimize air leakage.
6. Belt Drive:
    a. V-belt drive with automatic belt tension device.
    b. Minimum service factor of 1.2.
    c. Designed not to exceed allowable overhung load limits of blower and motor.
    d. Provide belt guard.

B. Motor:

1. Squirrel-cage ac induction type, meeting requirements of Section 26 20 00, Low-Voltage AC Induction Motors, and as specified herein.
2. Motor Horsepower: 30.
3. Nominal Speed: 3,600 rpm.
4. Rated Voltage: 460 volt, three-phase, 60-Hz.
5. Enclosure Type: ODP as specified in Section 26 20 00, Low-Voltage AC Induction Motors.
6. Inverter duty rated.
    a. Shaft grounding brush on the driven (shaft) end of the motor.
    b. Insulated bearing on the non-driven end of the motor.
7. Drive: V-belt drive.

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8. Motor Efficiency: Premium efficiency as specified in Section 26 20 00, Low-Voltage AC Induction Motors.
9. Service Factor: 1.15 when operated on a sinusoidal source; 1.0 when operated on an ac drive.
10. Thermistors woven into winding, not embedded in windings, are acceptable.

C. Blower Support:

1. Baseplate: Cast iron or fabricated steel mounted on concrete equipment pad as shown on Drawings.
2. Support Stand: Designed by manufacturer and shall be reinforced to withstand anticipated loadings of blower, motor, inlet and discharge silencers and associated piping.
3. Factory mount blower and motor as a package.
4. Provide vibration isolators to limit transmission of vibration to anchor points at floor.

2.03 ACCESSORIES

A. Air Inlet Filter:

1. Provide individual filters for each blower.
2. Filter efficiency shall meet ASHRAE 52.2 MERV7 50 to 70 percent at 3 to 10 microns.
3. Factory installed within sound enclosure.
4. Support leg height shall be field coordinated by Contractor.
5. Manufacturers:
   a. Universal.
   b. Stoddard.
   c. Or equivalent.

B. Inlet, Discharge Silencers:

1. Designed to reduce pulsation from rotary lobe blowers at blower operating timing gear speed.
2. For timing gear speeds below transition speeds, use a multi-chambered reactive type silencer, and for timing gear speeds at or above transition speed, use a multi-chambered reactive and absorptive type silencer packed with hair-felt packing.
3. Inlet/Outlet Air Velocity: 5,500 feet per minute, maximum.
4. Pressure Loss: 0.5 psid maximum combined loss, through silencers at design flow rate.
5. Inlet and outlet flanges shall match the piping size shown on Drawings and blower flanges. Flange drilling shall be 125-pound ANSI standard.
6. Provide drain coupling and plug.

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7. Mount as shown on Drawings.
8. Manufacturers and Products:
    a. Intake Silencer: Universal, Stoddard, or equivalent flanged inlet and discharge, modified as shown.
    b. Discharge Silencer: Universal, Stoddard, or equivalent flanged inlet and discharge, modified as shown complete with support base.

C. Flexible Connectors:

1. Pressure spool, single arch, expansion joint type with 125-pound ANSI flanges, sized to match blower flanges.
2. Operating Temperature Rating: 250 degrees F.
3. Install on each blower at inlet and outlet flange.
4. Thrust restraint rods on discharge if not otherwise restrained.
5. Manufacturers and Products:
    a. Mercer; Style 500.
    b. General Rubber; Style 1025.
    c. Vibraflex; PCS Series.
    d. Or equal.

D. Check Valve:

1. Wafer type for each blower; installed in blower discharge piping downstream of silencer and relief valve.
2. Cast iron body, stainless steel pin and spring, and two semicircular cast iron or aluminum plates.
3. Seat: Viton or Silicone for high temperature operation. Elastomeric hinges will not be allowed.
4. Manufacturer: Techno Corporation; or equivalent.

E. Safety Relief Valve:

1. Flanged, spring type.
2. Sized to relieve entire discharge flow without overloading blower.
3. Furnish one for each blower.
4. Relief valve shall be factor installed within sound enclosure and vented outside of the enclosure.

F. Temperature Sensor:

1. Provide HIGH discharge air temperature sensor, rated NEMA 4, for each blower.
2. Locate sensor directly after blower discharge within sound enclosure.

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G. Noise Enclosure:

1. Partial Noise Enclosure: 95 dBA average noise level at 1 meter.

H. Lifting Lugs: Provide suitably attached for equipment assemblies and components weighing over 100 pounds.

I. Equipment Identification Plates: Provide 16-gauge stainless steel identification plate securely mounted on each separate equipment component and control panel in a readily visible location. Plate shall bear 1/4-inch high die-stamped block type black enamel filled equipment identification number and letters indicated in this Specification.

J. Anchor Bolts: Type 316 stainless steel, sized by equipment manufacturer, and as specified in Section 05 50 00, Metal Fabrications.

2.04 INSTRUMENTATION AND CONTROLS

A. Instrumentation and controls work of this section shall be in accordance with Section 40 99 90, Package Control Systems. External signal interfaces are required to interface with facility's supervisory control and data acquisition (SCADA). Provide items not specifically called out which are required to implement functions required for proper system operation.

B. Control Panel:

1. Panel Power Requirements: 120V ac, single-phase, 20 amp.
2. NEMA Rating: 4.
3. Mounting: Pedestal.
4. Hand Switches:
    a. Disconnect switch.
    b. LOCAL/OFF/REMOTE.
    c. START/STOP.
    d. RESET for blower fail.
5. Indicating Lights:
    a. Blower FAIL.
    b. HIGH differential air pressure.
    c. Amber STOP.
    d. Blower ON.
    e. Blower OFF.
6. Miscellaneous:
    a. RUN time meter.
    b. High inlet vacuum shutdown.
    c. Discharge High Temperature Shutdown: 0 degree to 350-degree range, NEMA 4 mounted, field adjustable, as manufactured by Ashcroft.

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d. Discharge High Pressure Shutdown: 5 psig to 15 psig range, NEMA 4 mounted, field adjustable, as manufactured by Ashcroft.
e. Inlet and Discharge Pressure Gauges: Liquid filled, 4.5-inch face, as manufactured by Ashcroft.
f. Inlet and Discharge Temperature Gauges: Minus 20 degrees F to 120 degrees F inlet, 50 degrees F to 400 degrees F discharge, 5-inch-diameter dial every angle, as manufactured by Ashcroft.

C. Control Panel External Interfaces:

1. Discrete Outputs to SCADA:
   a. Dry contacts shall be noble metal or hermetically sealed, and suitable for 5 amps at 120V ac.
   b. REMOTE status.
   c. Common FAIL alarm contact that closes on the occurrence of any of the following conditions (to be used by SCADA):
      1) HIGH differential air pressure.
      2) HIGH discharge temperature.
      3) Motor OVERTEMP.
2. Discrete Outputs to MCC:
   a. Dry contacts rated for 10 amps at 120V ac for use in motor starter circuit.
   b. RUN.
3. Discrete Inputs:
   a. Contact Rating: 5 amps at 120V ac.
   b. Sensing Voltage: 120V ac.
   c. START/STOP from SCADA.
   d. HIGH differential air pressure from field devices.
4. Discrete Inputs from MCC:
   a. Dry contacts rated for 10 amps at 120V ac for use in motor starter circuit.
   b. Sensing Voltage: 120V ac supplied by control panel.
   c. Blower ON.
   d. Motor OVERTEMP.
5. Signals that interface with SCADA shall be wired to a terminal block in each panel.
6. Contacts:
   a. Material: Gold or silver.
   b. Minimum Rating: 5 amps, 28V dc.
   c. Discrete Outputs:
      1) Alarm: Single-pole, double-throw (SPDT) dry type.
      2) Other: Single-pole, single-throw (SPST) dry type.
   d. Wire each discrete alarm output relay contact to a terminal strip for interfacing to SCADA.

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D. System Operation:

1. Functional Requirements: Provide at each panel.
    a. RESET pushbutton and associated logic for the common FAIL alarms. When alarm condition occurs, indicate associated condition at panel. Local indication of alarm condition shall remain until condition has been corrected and RESET pushbutton pressed.
    b. Control logic to monitor operation of blower and provide a contact closure output to motor control center when prestartup or operating conditions are normal. Open contact if a HIGH differential air pressure between blower inlet and outlet condition or HIGH discharge air temperature is detected.
    c. Indicate blower shutdown and problem using latching relays.

2.05 SHOP/FACTORY FINISHING:

A. Prepare and prime, and finish coat all bare ferrous metal, including blowers and accessories, in accordance with Section 09 90 00, Painting and Coating.

2.06 SOURCE QUALITY CONTROL

A. Blower Performance Test:

1. Notify Engineer at least 7 days prior to performing test.
2. Perform on the blower actually furnished in accordance with manufacturer's established criteria.
3. Test each blower for a minimum of 1 hour after stabilization at conditions near the performance ratings for mechanical integrity and flow performance.
    a. Perform at or above specified performance pressure rise.
    b. Tolerance on Flow: Plus or minus 4 percent, after correction to rated conditions.
4. Perform Slip Test in accordance with manufacturer's established criteria.
    a. Describe the testing configuration.
    b. Document operating conditions, temperatures, pressures, blower speed, etc.
    c. Complete slip calculations at test conditions.
5. Measure power consumption using a calibrated wattmeter.
6. Test Report: Confirm capacity and power, complete with data and calculations used in the test.

B. Motor Test: See Section 26 20 00, Low-Voltage AC Induction Motors.

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PART 3 EXECUTION

3.01 INSTALLATION

A. In accordance with manufacturer's written instructions.

B. Install one check valve in the blower discharge piping, downstream of the silencer and safety relief valve.

C. Anchor Bolts: Accurately place using templates furnished by manufacturer and as specified in Section 05 50 00, Metal Fabrications.

D. Install blower package on vibration isolators and anchor bolts in strict accordance with manufacturer's written instructions.

3.02 FIELD QUALITY CONTROL

A. In accordance with Section 01 91 14, Equipment Testing and Facility Startup.

B. Functional Test: Prior to facility startup, conduct on each Blower System, assisted by manufacturer's representative, for correct rotation, proper alignment and connection, quiet operation, and satisfactory specified performance.

3.03 MANUFACTURER'S SERVICES

A. Manufacturer's Representative: Present at Site or classroom designated by Owner, for minimum person-days listed below, travel time excluded:

1. 1-person-day for installation assistance and inspection.
2. 1-person-day for functional testing and completion of Manufacturer's Certificate of Proper Installation.
3. 1-person-day for post-startup training of Owner's personnel.

B. See Section 01 43 33, Manufacturers' Field Services, and Section 01 91 14, Equipment Testing and Facility Startup.

END OF SECTION

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SECTION 44 42 28
WEIR AND BAFFLE PLATES

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Water Works Association (AWWA): F102, Matched-Die-Molded, Fiberglass-Reinforced Plastic Weir Plates, Scum Baffles, and Mounting Brackets.
2. ASTM International (ASTM):
   a. A167, Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
   b. A193/A193M, Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications.
   c. A194/A194M, Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High Pressure or High Temperature Service, or Both.
   d. A276, Standard Specification for Stainless Steel Bars and Shapes.
   e. B209, Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
   f. B308/B308M, Standard Specification for Aluminum-Alloy 6061-T6 Standard Structural Profiles.
   g. C581, Standard Practice for Determining Chemical Resistance of Thermosetting Resins Used in Glass-Fiber-Reinforced Structures Intended for Liquid Service.
   h. C920, Standard Specification for Elastomeric Joint Sealants.
   i. D256, Standard Test Methods for Determining the Izod Pendulum Impact Resistance of Plastics.
   j. D570, Standard Test Method for Water Absorption of Plastics.
   k. D638, Standard Test Method for Tensile Properties of Plastics.
   l. D790, Standard Test Methods for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials.
   m. D2583, Standard Test Method for Indentation Hardness of Rigid Plastics by Means of a Barcol Impressor.

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1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Detailed description of laminate and type of reinforcing to be used.
   b. Manufacturer's drawings showing dimensions of the items and accessories being provided.
   c. Complete information regarding specific resin to be used.
   d. **[A: .]**
2. Sample: Manufacturer's 6-inch square sample of fiberglass reinforced plastic laminate of same construction, nominal thickness, and color as materials specified.

B. Informational Submittals:

1. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements, and stating the following:
   a. Reinforcing material used will provide suitable chemical resistance.
   b. Resin is suitable for the environmental conditions intended and the fabrication technique proposed.
2. **[C: .]**

1.03 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to Site properly packaged for ease of handling and to minimize damage during shipping.

B. Handling and storage of items provided hereunder shall be in strict accordance with manufacturer's printed instructions. Care shall be taken not to damage components and accessories.

PART 2 PRODUCTS

2.01 GENERAL

A. Like items of equipment specified herein shall be the end products of one manufacturer in order to achieve standardization of appearance, operation, maintenance, and manufacturers' services.

B. Coordinate scum baffle configuration with equipment, such as a scum skimmer, that will physically interface with baffle to ensure proper functioning of system.

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2.02 MATERIALS

A. Stainless Steel:

1. Plate, Baffles, and Supports: ASTM A167 and ASTM A276, minimum: 5/16 inch thick.
2. Fasteners: ASTM A193/A193M and ASTM A194/A194M, Type 316.

2.03 APPURTENANCES

A. Sealant:

1. Polyurethane base, single-component, moisture curing, ASTM C920, Type S, Grade NS or P, Class 25.
2. Capable of being continuously immersed in water.
3. Manufacturers and products:
   a. Sika Chemical Corp.; Sikaflex-1a.
   b. Mameco International; Vulkem 45.

B. Anchoring: Type 316 stainless steel adhesive anchors as specified in Section 05 50 00, Metal Fabrications.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in strict accordance with the manufacturer's written instructions.

B. Sealant:

1. Clean and prepare concrete and weir plate surfaces in accordance with sealant manufacturer's recommendations.
2. Application:
   a. In accordance with manufacturer's instructions.
   b. Completely cover the interface between the weir plate and mounting surface over the full height of the weir plate.
   c. Apply sufficiently to completely fill any gaps between the weir plate and the supporting wall surface.
   d. Clean excess sealant that is forced from between the weir plate and supporting wall as the plate is tightened against the wall surface to provide a neat installation.
   e. Clean all adjacent surfaces of smears or soiling.

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3.02 TESTS AND INSPECTION

A. In accordance with Section 01 91 14, Equipment Testing and Facility Startup.

B. Functional Test: Demonstrate proper installation of weir plate for both water tightness and level, prior to placing unit into service, by filling unit with water to the weir crest elevation. Make adjustments as necessary to meet specification.

END OF SECTION

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SECTION 44 42 56.03
VERTICAL TURBINE PUMPS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Bearing Manufacturers Association (ABMA):
   a. 9, Load Ratings and Fatigue Life for Ball Bearings.
   b. 11, Load Ratings and Fatigue Life for Roller Bearings.
2. American Welding Society (AWS):
   a. AWS D1.1/D1.1 M-08 Structural Welding Code – Steel.
3. American Society of Mechanical Engineers (ASME)
   a. ASME BPVC-IX (2013) Boiler and Pressure Vessel Code - Section IX - Welding and Brazing Qualifications.
4. American Petroleum Institute (API):
   a. 610, Centrifugal Pumps for Petroleum, Petrochemical, and Natural Gas Industries.
   b. 670, Machinery Protection Systems.
5. ASTM International (ASTM):
   a. A36/A36M, Standard Specification for Carbon Structural Steel.
   b. A536, Standard Specification for Ductile Iron Castings.
   c. B584, Standard Specification for Copper Alloy Sand Castings for General Applications.
6. American National Standards Institute / Hydraulic Institute Standards (ANSI/HI):
   a. ANSI/HI 2.1 - 2.4 (2014), Rotodynamic (Vertical) Nomenclature.
   b. ANSI/HI 2.3 (2013), Rotodynamic (Vertical) Pumps for Design and Application.
   c. ANSI/HI 2.4 (2014), Rotodynamic (Vertical) Pumps for Manuals Describing Installation, Operation, and Maintenance.
      ANSI/HI 9.6.2 (2015), Rotodynamic Pumps for Assessment of Applied Nozzle Loads.
   d. ANSI/HI 9.6.4 (2009), Rotodynamic Pumps for Vibration Measurements and Allowable Values.
   e. ANSI/HI 9.8 (2012), Pump Intake Design Standard.
   f. ANSI/HI 14.6, Rotodynamic Pumps for Hydraulic Performance Acceptance Tests.
7. National Electrical Manufacturer’s Association (NEMA):
   a. NEMA MG 1 (2014), Motors and Generators.
   b. NEMA 250 (2014), Enclosures for Electrical Equipment (1000 Volts Maximum).

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8. NSF International (NSF):
    a. NSF/ANSI 61, Drinking Water System Components - Health Effects.
    b. NSF/ANSI 372, Drinking Water System Components - Lead Content.
9. International Standard Organization (ISO):
    a. ISO 1940-1: 2003, Mechanical Vibration.

1.02 DEFINITIONS

A. Terminology pertaining to pumping unit performance and construction shall conform to the ratings and nomenclature of the Hydraulic Institute Standards.

1.03 SUBMITTALS

A. Action Submittals:

1. Make, model, weight, and horsepower of each equipment assembly.
2. Complete catalog information, descriptive literature, specifications, and identification of materials of construction.
3. Performance data curves showing head, capacity, horsepower demand, NPSH required, and pump efficiency over the entire operating range of the pump, from shutoff to maximum capacity. Indicate separately the head, capacity, horsepower demand, overall efficiency, and minimum submergence required at the design flow conditions.
4. Calculations:
    a. Torsional analysis for complete rotating assembly. Analysis report shall include the specific items of API 610, Part 2.8, Dynamics.
    b. Lateral vibration analysis for discharge head motor assembly and for column pipe bowl assembly.
    c. Seismic analysis for discharge head, equipment support and anchors, and column pipe bowl assembly.
    d. Discharge head deflection analysis, including nozzle loading requirements based on ANSI/HI 9.6.2.4.
5. Reverse Runaway Speed: Pump manufacturer’s estimated maximum reverse runaway speed for pump and motor assembly. Submit coincident reverse flow and pump head for speed estimates.
6. Pump maximum downthrust or upthrust in pounds.
7. Detailed structural, mechanical, and electrical drawings showing equipment dimensions, size, and locations of connections and weights of components.
8. Assembly and installation drawings including shaft size, seal, coupling, bearings, anchor bolt plan, parts nomenclature, and materials of construction lists.

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9. Baseplate drawings with leveling jackscrew details, anchor bolt and sleeve details, and minimum foundation installation and leveling requirements.
10. Power and control wiring diagrams, including terminals and numbers.
11. Complete motor nameplate data, as defined by NEMA, motor manufacturer, including motor modifications.
12. Factory finish system.
13. Vibration monitoring system information including technical product bulletins and descriptions, specification data sheets, wiring diagrams, communications hardware and software, documentation sufficient for configuration of functions specified herein and shown on Drawings.
14. Seismic anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.

B. Informational Submittals:

1. Seismic anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements, that factory finish system is identical to requirements specified herein.
3. Special shipping, storage and protection, and handling instructions.
4. Manufacturer's printed installation instructions.
5. Government witnessed Factory Functional and Performance Test Reports and Log. Factory test data for each pump shall be submitted, reviewed, and approved by Engineer prior to shipment of equipment.
6. Suggested spare parts list to maintain equipment in service for a period of 1 year and 5 years. Include a list of special tools required for checking, testing, parts replacement, and maintenance with current price information.
7. List special tools, materials, and supplies furnished with equipment for use prior to and during startup and for future maintenance.
8. Operation and Maintenance Data: As specified in Section 01 78 23, Operation and Maintenance Data.
9. Manufacturer's Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers' Field Services.

1.04 EXTRA MATERIALS

A. Provide spare parts that are new, not refurbished, and properly packed for long-term storage. Furnish spare parts that are interchangeable with and of the same materials and workmanship as corresponding original pump and motor parts. Clearly mark or tag each part to identify size and type of pumping unit it is intended.

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B. Furnish the following for each set of pumps:

1. Complete set packing. (x1).
2. Complete set bearings. (x1).
3. Complete set gaskets and O-ring seals. (x1).
4. Complete set of shaft sleeves. (x1).
5. Complete set keys, dowels, pins, etc. (x1).
6. Complete mechanical seal. (x1).
7. Impeller. (x1).
8. Impeller wear ring. (x1 per Stage).
9. Bowl wear ring. (x1 per Stage).
10. Complete set motor bearings. (x1).
11. Spare bearing temperature relay. (x1).
12. Complete set of special tools required to dismantle pump. (x1 per pump model):
    a. Special tools are those tools, which because of their limited use, are not normally available but are necessary for the particular equipment specified.
    b. Furnish tools of high-grade, forged alloy, tool steel.
    c. Furnish a steel box for storage of the special tools.
    d. Furnish list of wrenches, tools, and accessories being furnished.

PART 2 PRODUCTS

2.01 GENERAL

A. Adjustable Speed Drives:

1. Where required, furnish coordinated operating system complete with pump, driver, and speed controller.
2. Coordinate pump and motor requirements with adjustable speed drive manufacturer and be responsible for the following:
    a. Torsional vibration of rotating assembly and related stresses.
    b. Motor thermal rating.
    c. Structural design of pump and motor assembly.
    d. Drive capacity for actual motor’s nameplate current rating being supplied.
    e. Minimum motor speed rating for required corresponding torque.

B. Lateral and Torsional Vibrations:

1. Pump and motor assembly shall have no natural frequencies within 20 percent of operating speed range.
2. Fundamental critical speed of rotating assembly shall be no less than 50 percent above the rated speed.

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3. Pump manufacturer shall conduct an analysis of the lateral and torsional vibration of pump and motor assembly.
    a. Excitation frequency range of the analysis shall include, but not be limited to, number of motor poles and number of impeller vanes.
    b. Perform detailed stress analysis for pump, coupling, motor system at each critical speed, and steady-state operating condition.
    c. Stress analysis shall demonstrate that in no case shall maximum stress on pump, coupling and motor component exceed endurance limits of pump, coupling and motor assembly components materials of construction.

C. Components and Materials in Contact with Water for Human Consumption: Comply with the requirements of the Safe Drinking Water Act and other applicable federal, state, and local requirements. Provide certification by manufacturer or an accredited certification organization recognized by the Authority Having Jurisdiction that components and materials comply with the maximum lead content standard in accordance with NSF/ANSI 61 and NSF/ANSI 372.

1. Use or reuse of components and materials without a traceable certification is prohibited.

2.02 SUPPLEMENTS

A. Some specific requirements are attached to this section as supplements.

2.03 SHAFT SEALS

A. Sealing system for vertical turbine pump shafts shall be mechanical seal or packed stuffing box as indicated in pump data sheet.

B. Mechanical Seal Requirements:

1. Nonfretting type requiring no wearing sleeve for shaft.
2. Shafts for pumps specified with mechanical seals shall be furnished with no reduction in size through seal area.
3. Split Type:
    a. Requiring no field assembly other than assembly around shaft and insertion into pump or balanced cartridge design in conjunction with a spool type spacer coupling as specified in pump data sheet.
    b. Nonshaft O-rings: Ball and socket type requiring no gluing.
    c. Initial seal installation at factory shall be with nonsplit seal faces; spare seals and spare kits to have split faces.

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d. Unless otherwise specified, capable of 400 psig service, be self-aligning, self-centering, and single.
e. Manufacturer and Product: A.W. Chesterton Company; No. 442.

4. Arrangement shall allow removal of seal without disturbing pump or driver.
5. For clear water services and solids up to 5 percent by weight, face combination shall be hard/soft. Otherwise, hard/hard faces shall be used.
6. Design such that dynamic O-ring moves towards a clean surface as face wears and springs are not in pumped fluid.
7. Stationary seal face shall be spring loaded to provide self-aligning despite stuffing box misalignment.
8. Where cartridge type mechanical seals are specified:
   a. Single, balanced, flexible stator design.
   b. Capable of 600 psig service.
   c. O-ring secondary seals and setscrew drive with three-point centering to ensure 0.003-inch maximum perpendicularity of rotary face to shaft.
   d. Gland shall have flush port and be affixed to equipment with adjustable tabs to fit irregular bolt patterns.
   e. Manufacturers and Products:
      1) A.W. Chesterton Company; 155.
      2) Crane; 1B.
9. Seal Materials:
   a. Metals:
      1) Loaded Parts Over 0.060-inch Cross Section: Type 316 stainless steel minimum.
      2) Thinner Parts (springs): Hastelloy-C, Alloy 20, AMS5876 Elgiloy, or other alloy that is not vulnerable to chloride stress corrosion.
   b. Elastomers: Fluorocarbon Viton preferred, unless seal manufacturer recommends ethylene propylene for service conditions.
   c. Faces: Homogeneous construction. Surface treatments and plated faces are unacceptable.
      1) Acceptable hard faces include nickel bound tungsten carbide, self-sintered silicon carbide, reaction bonded silicon carbide, or graphitized silicon carbide. Silicon carbide is preferred because of its higher pressure-velocity capability.
      2) Acceptable soft face is carbon-graphite, either Union Carbide 658RC or Purecarbon P8412.
10. Seal Environmental Controls:
    a. Pipe seal flush port drain to wetwell or hub drain as shown on Drawings with 1/8-inch orifice plate in the line. Provide venting of seal chamber.

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b. Mechanical seals for anything other than clear water services shall be fitted with Enviroseal SpiralTrac Version F, N, or D, installation Type I as recommended by A.W. Chesterton Company.
   1) Provide fluid circulation in seal chamber that removes frictional heat from mechanical seal.
   2) Convey particulate matter and contaminants for removal by conveying them from bore to shaft by means of integral machined spiral.
   3) Remove particulate matter from seal chamber, without seal flush water, through integral machined exit groove.
c. Material of Construction: Type 316 stainless steel.
d. Connect mechanical seal to water purge supply where indicated on Drawings.

C. Packing Requirements:

1. Stuffing Box:
   a. Tap to permit introduction of seal liquid.
   b. Hold a minimum of five rows of packing and a lantern ring.
   c. Face attached.
   d. Box and shaft shall be suitable for field installation without machining or other modifications of mechanical seal specified herein for applicable pump and operating conditions.
2. Packing Rings:
   a. Three asbestos free die-molded packing rings of braided graphite material free of PTFE.
      1) A.W. Chesterton Company; 1400R for nonpotable water services.
   b. Three die-molded rings of braided PTFE material.
      1) A.W. Chesterton Company; 1725 that is NSF/ANSI 61 acceptable for potable water services.
   c. Glands:
      1) Two-piece split construction.
      2) Fit impeller end of packing with A.W. Chesterton Company; Enviroseal SpiralTrac, Version P, packing protection.
3. Where pumped fluid is clear water:
   a. Pump discharge run through 1/8-inch orifice for packing lubrication. Otherwise, provide seal water flow control and monitoring as detailed on Drawings.
   b. External Seal Water Flow: 5 gallons to 30 gallons per hour flow rate, plus or minus 10 percent accuracy.
   c. Manufacturer and Product: A.W. Chesterton Company; SingleFlow.

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4. Shaft Sleeve:
    a. Fit section of shaft or impeller hub that extends through or into stuffing box with replaceable stainless steel sleeve with a Brinell hardness of not less than 500.
    b. Sleeve shall be held to shaft to prevent rotation.
    c. Gasketed to prevent leakage between shaft and sleeve.
    d. Thickness: 3/8-inch minimum.

2.04 VIBRATION AND TEMPERATURE TRANSDUCERS AND MONITORING SYSTEM

A. General:

1. Meet requirements specified herein and with motor temperature and vibration sensors specified in Section 26 20 00, Low-Voltage AC Induction Motors.
2. Provide temperature and vibration monitoring systems in cabinet as shown in Process and Instrumentation Diagram (P&ID), program, test, calibrate, fully configure and place into operation.

B. Features:

1. Microprocessor based system with programmable firmware options.
2. Programmable operating range.
3. Programmable alarm delays.
4. Four-channel modules.
5. AND or OR danger voting logic.
6. Timed OK/Channel defeat.
7. Ethernet and serial communication interface selections to plant control system.
8. Include 7-position or 14-position slot rack(s) which shall contain the following types of plug in modules:
    a. Power supply module.
    b. Rack interface module.
    c. One or more radial vibration velocity monitoring module as required.
    d. One or more thrust (axial) vibration velocity monitoring module as required.
    e. One dual channel phase reference (timing) monitoring module.
9. Interconnected to each other and to remote terminal unit (RTU) via ethernet or serial communications as required. This communications link shall effectively communicate data relevant to operating purpose of vibration monitoring systems. Provide data configuration software and documentation to allow communication with RTU.
10. Configure alarm contacts to be normally closed, open in alarm condition and open on loss of power.

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11. Cables requiring special calibration for optimum performance shall be calibrated by the Bently Nevada Corporation or an authorized representative thereof.
12. Manufacturer and Product: Bently Nevada Corporation; 3500 Series.

C. Bearing Housing Vibration Velocity Transducers:

1. Permanently installed accelerometers by pump manufacturer.
2. Located at top flange of discharge head.
3. Two radial velocity transducers shall be provided with one measuring discharge nozzle direction and one at 90 degrees to discharge nozzle direction.
4. Elements:
    a. Accelerometers, providing inches per second RMS (root mean squared) velocity output.
    b. Minimum Rated Operating Frequency: Less than minimum pump operating speed.
    c. Vibration element shall include shielded signal cable and be enclosed in NEMA 4X housing.

D. Bearing Temperature Elements:

1. Permanently installed by motor manufacturer.
2. Sensor shall be as specified in Section 26 20 00, Low-Voltage AC Induction Motors.

E. Motor Casing Velocity Transducer: As specified in Section 26 20 00, Low-Voltage AC Induction Motors.

F. Vibration and temperature transducers shall be installed in accordance with guidelines provided by API 670.

G. Provide terminal junction box mounted on pump discharge head. Provide conduit and cable from pump vibration transducers to terminal junction box.

2.05 ACCESSORIES

A. Equipment Identification Plate: 16-gauge stainless steel with 1/4-inch die-stamped equipment tag number securely mounted in a readily visible location.

B. Lifting Lugs: Equipment weighing over 100 pounds.

C. Anchor Bolts: Type 316 stainless steel, sized by equipment manufacturer, and as specified in Section 05 50 00, Metal Fabrications.

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2.06 FACTORY FINISHING

A. Prepare and prime, and finish coat in accordance with Section 09 90 00, Painting and Coating **[C: Manufacturer's standard [D: baked] enamel finish].**

2.07 SOURCE QUALITY CONTROL

A. **[A: Factory Inspections:] Inspect [B: control panels] [C:]** for required construction, electrical connection, and intended function.

B. **[A: Factory Tests and Adjustments:] Test [B: one] [C:] [D: all] [E: equipment] [F:] [G: and] [H: control panels [I: actually] [J: identical to that]] furnished.**

C. **Factory Test Report: Include [A: test data sheets,] [B: curve test results,] [C: performance test logs,] [D: certified correct by a registered professional engineer].**

D. Functional Test: Perform manufacturer's standard, motor test on equipment. Include vibration test, as follows:

1. Dynamically balance rotating parts of each pump and its driving unit before final assembly.
2. Limits:
    a. Driving Unit Alone: Less than 80 percent of NEMA MG 1 limits.
    b. Complete Rotating Assembly Including Coupling, Drive Unit, and Motor: Less than 90 percent of limits established in the Hydraulic Institute Standards.

E. Performance Test:

1. Conduct on each pump at rated speed.
2. Perform under simulated operating conditions.
3. Test for a continuous 3-hour period without malfunction.
4. Test Log: Record the following:
    a. Total head.
    b. Capacity.
    c. Horsepower requirements.
    d. Flow measured by factory instrumentation and storage volumes.
    e. Average distance from suction well water surface to pump discharge centerline for duration of test.
    f. Pump discharge pressure converted to feet of liquid pumped and corrected to pump discharge centerline.

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g. Calculated velocity head at the discharge flange.
h. Bowl head.
i. Driving motor voltage and amperage measured for each phase.

5. Adjust, realign, or modify units and retest in accordance with Hydraulic Institute Standards if necessary.

F. Motor Test: See Section 26 20 00, Low-Voltage AC Induction Motors.

G. Hydrostatic Tests: Pump casing(s) tested at 150 percent of shutoff head. Test pressure maintained for not less than 5 minutes.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer's printed instructions.

B. Level base by means of steel wedges (steel plates and steel shims). Wedge taper not greater than 1/4 inch per foot. Use double wedges to provide a level bearing surface for pump and driver base. Accomplish wedging so there is no change of level or springing of baseplate when anchor bolts are tightened.

C. Adjust pump assemblies such that driving units are properly aligned, plumb, and level with driven units and interconnecting shafts and couplings. Do not compensate for misalignment by use of flexible couplings. Shaft alignment shall be laser aligned and report submitted as part of Functional Testing.

D. After pump and driver have been set in position, aligned, and shimmed to proper elevation, grout space between bottom of baseplate and concrete foundation with a poured, nonshrinking grout of the proper category, as specified in Section 03 62 00, Nonshrink Grouting. Remove wedges after grout is set and pack void with grout.

E. **[A: Vibration and Temperature Transducers:**

1. **Install in accordance with API 670.**
2. **Install two terminal junction boxes mounted on motor housing.**
3. **Install conduit and cable from motor bearing temperature transducers to one of the terminal junction boxes. Install conduit and cable from motor vibration transducers to the other junction box.]**

F. Connect suction and discharge piping without imposing strain to pump flanges.

G. Anchor Bolts: Accurately place using equipment templates and as specified in Section 05 50 00, Metal Fabrications.

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3.02 FIELD FINISHING

A. As specified in Section 09 90 00, Painting and Coating.

3.03 FIELD QUALITY CONTROL

A. Functional Tests: Conduct on each pump.

1. Alignment: Test complete assemblies for correct rotation, proper alignment and connection, and quiet operation. Shaft alignment shall be laser aligned and report submitted as part of Functional Testing documents.
2. Vibration Test:
   a. Test with unit installed and in normal operation, and discharging to connected piping systems at rates between low discharge head and high discharge head conditions specified, and with actual building structures and foundations provided shall not develop vibration exceeding 80 percent of limits specified in HIS 9.6.4.
   b. If unit exhibits vibration in excess of limits specified, adjust or modify as necessary. Unit that cannot be adjusted or modified to conform as specified shall be replaced.
3. Flow Output: Measured by plant instrumentation and storage volumes.
4. Operating Temperatures: Monitor bearing areas on pump and motor for abnormally high temperatures.
5. Test for continuous 3-hour period.
6. Test Report Requirements: In accordance with HIS 14.6.

B. Performance Test: In accordance with Hydraulic Institute Standards.

3.04 MANUFACTURER'S SERVICES

A. Manufacturer's Representative: Present at Site or classroom designated by **[A: Owner,] [B:]** for minimum person-days listed below, travel time excluded:

1. **[C:] person-days for [D: installation assistance] [E: and] [F: inspection]**.
2. **[G:]** person-days for **[H: functional] [I: and] [J: performance]** testing and completion of Manufacturer's Certificate of Proper Installation.
3. **[K:]** person-days for prestartup classroom or Site training.
4. **[L:]** person-days for facility startup.
5. **[M:] person-days for post-startup training [N: of Owner's personnel]. [O: Training shall not commence until an accepted detailed lesson plan for each training activity has been reviewed by [P: Owner] [Q: Engineer] [R:].]**

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B. **See [A: Section 01 43 33, Manufacturers' Field Services] [B: and] [C: Section 01 91 14, Equipment Testing and Facility Startup.]**

3.05 SUPPLEMENTS

A. The supplements listed below, following "End of Section," are a part of this Specification.

1. Vertical Turbine Finished Water Pump Data Sheet.
2. Vertical Turbine BWS Pump Data Sheet.

END OF SECTION

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Pump Data Sheet - General Requirements

Vertical Turbine	44 42 56.03

Project name	Cutter Lateral Water Treatment Plant
Project number	682853
Owner	
Part Name	Finished Water Pumps
Equipment Tag No. (if applicable)	PMP36010401; PMP36010403; PMP36020401; PMP36020403
Unit No. (if applicable)	
Service Name	FW
Pump Manufacturer & Model	Flowserve 12EMM or Equal

Marking notes: X=required, NA=not applicable, NR=not required(optional mark), Mfr Std=manufacturer's standard is acceptable.

PROJECT REQUIREMENTS		
Pumped Liquid Properties	Value or note	Unit of Measure
Pumped Liquid	Finished Water (FW)	----
Maximum Pumping Temperature	72	degree F
Minimum Pumping Temperature	39	degree F
Specific Gravity @ Min Temp	1	
Vapor Pressure @ Max Temp	0.39	psia
Viscosity @ Min Temp	1.794	cP
pH Range	6.5-7.5	----
Ambient Temperature Range (Min-Max)	-10-110	degree F
Pump Centerline Location (above MSL)	6637	ft MSL
Abrasives	None	
Min NPSH Available (NPSHA)	23.9	ft-abs H_2O
Pump Location Relative Humidity	3-99	%
Minimum Submergence	2.5	ft H_2O

DESIGN REQUIREMENTS		
Pump Performance	Required if noted or value entered	Unit of Measure
Design Duty Point		
Flow Rate	**810**	gpm
Total Dynamic Head	**420**	ft H_2O
Minimum Efficiency	**75**	%
Maximum NPSH Required	23	ft-abs H_2O
Speed	1770	rpm
Secondary Point		
Flow		gpm
Total Dynamic Head		ft H_2O
Minimum Bowl Efficiency		%
Maximum NPSH Required		ft-abs H_2O
Shutoff Head		ft H_2O
Adjustable Speed Performance:		
Maximum speed		--
Flow Rate		gpm
Total Dynamic Head		ft H_2O
Minimum Bowl Efficiency		%

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Secondary Point @ Maximum Speed		--
Flow		gpm
Total Dynamic Head		ft H_2O
Minimum Bowl Efficiency		%
Shutoff Head		ft H_2O
Minimum Speed		--
Flow Rate	354	gpm
Total Dynamic Head	388	ft H_2O
Minimum Bowl Efficiency		%
Secondary Point @ Minimum Speed		--
Flow		gpm
Total Dynamic Head		ft H_2O
Minimum Efficiency		%
Shutoff Head		ft H_2O

Minimum Moment of Inertia	Required if value entered	Unit of Measure
Pump		$ft\text{-}lb^2$
Motor		$ft\text{-}lb^2$

Pump Configuration	Required if noted or value entered	Unit of Measure
Baseplate & Frame	Mfr Std	
Drive/Pump Coupling Type	**Mfr Standard**	
Number of Impeller Stages	**6**	
Bowl Assembly	**Flanged**	
Impeller Rotation as Viewed From Driver End	**Counterclockwise**	
Lineshaft	**Open**	
Maximum Lineshaft Section Length	**10**	ft
Lineshaft Connection Method	**Threaded**	
Maximum Lineshaft Bearing Span	**10**	ft
Coloumn Assembly Method	**Flanged**	
Seal type - Mechanical	**NA**	
Seal type - Packing	**X**	
Seal Lubrication	**NA**	
Bearing Lubrication	**Internal Fluid**	
DIMENSION AND SIZES		
Pump Discharge	**----**	
Discharge Nozzle Nominal Size	**6**	inches
Discharge Nozzle, Plain End withThrust Tie Legs	**NR**	
Discharge Flange Size	**6**	inches
Discharge Flange Rating, ANSI B16.1	**250**	

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Pump Suction	----	
Suction Can, Nominal Diameter	**NA**	inches
Suction Can Flange Rating, ANSI B16.1	**NA**	
Suction Can, Bottom Elevation	**NA**	ft
Suction Can Nozzle, Centerline Elevation	**NA**	ft
Column Piping Length	**As Required**	ft
Discharge Head, Centerline Elevation	**6637**	ft
Sump Floor Elevation	**6615**	ft
Bottom of Sole Plate Elevation	**As Required**	ft
Bowl Diameter	**Mfr Std**	inches
Suction Bell Diameter	**Mfr Std**	inches
PUMP DRIVER		
Driver	**Motor**	
ACCESSORIES		
Coupling Guard	**X**	
Sole Plate	**X**	
Seal Water Set	**NR**	
Bearing Lubricator	**NR**	
Enclosed Lineshaft Bearing Oil Lubrication	**NR**	
Suction Bell Strainer	**X**	
FACTORY FINISHING		
Prepare, and prime, and finish coat in accordance with Section 09 90 00, Painting	**NR**	
FACTORY TESTING		
Shop Performance Test	**X**	
Owner/Design-Builder Witnessed	**X**	
FIELD TESTING		
Functional Test	**X**	
Field Acceptance Test	**X**	
Field Installation Certification	**X**	
ANALYSIS REQUIREMENTS		
Lateral Vibration Analysis	**NR**	
Torsional Vibration Analysis	**NR**	
Reverse Runaway Speed Analysis	**NR**	

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Remarks / Special Features
There shall not be any flow gaps when transitioning from 1 duty pump to 2

Special Warranty Requirements
(Identify specific requirements)

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Pump Data Sheet - Material Requirements

Vertical Turbine 44 54 56.03

Project name	Cutter Lateral Water Treatment Plant
Project number	682853
Owner	0
Part Name	Finished Water Pumps
Equipment Tag No. (if applicable)	PMP36010401; PMP36010403; PMP36020401; PMP36020403
Unit No. (if applicable)	0
Service Name	FW
Pump Manufacturer & Model	Flowserve 12EMM or Equal

Materials of Construction

General Material Requirement	◉ **Bronze Trimmed Iron** ○ **Zincless Bronze Trimmed Iron**

PUMP ASSEMBLY COMPONENTS

PART	Alternate Material Required	MATERIAL	Reference Standard
Impeller	☑	316LSS	
Shaft, pump	☑	Stainless Steel	ASTM No. A582-416
Bearings, Pump & Bowl	☑	Thordon SXL	
Casing, Pump & Bowl	☑	316LSS	
Lineshaft	☑	316LSS	
Bearing, Lineshaft[1]	☑	Rubber Buna-N	
Sleeve, Lineshaft	☐	Stainless Steel	ASTM No. A582-416
Retainer, Bearing	☐	Bronze	ASTM No. B854 C83600
Enclosing Tube	☐	Steel	ASTM No. A120, Schedule 80
Column, Pump	☐	Steel	ASTM No. A53
Suction Bell	☑	Cast Iron	ASTM No. A48 CL30
Deflector	☐	Neoprene	Commercial
Discharge Head	☐	Cast Iron	ASTM No. A48 CL30
Base Plate (option 1)	☐	Cast Iron	ASTM No. A48 CL30
Base Plate (option2)	☐	Steel	ASTM No. A36
Stuffing Box	☐	Cast Iron	ASTM No. A48 CL30

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Bushing, Stuffing Box	☐	Bronze	ASTM No. B854 C83600
Gland	☐	Bronze	ASTM No. B148 HT
Gland Studs	☐	Stainless Steel	ASTM No. A582-303
Ring, Lantern	☐	Virgin Teflon	Commercial
Grease Fitting	☐	Mfr Std	Commercial

Remarks / Special features / Spare Parts

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Pump Data Sheet - Motor Requirements	
Vertical Turbine	**44 42 56.03**

Project name	Cutter Lateral Water Treatment Plant
Project number	682853
Owner	0
Part Name	Finished Water Pumps
Equipment Tag No. (if applicable)	PMP36010401; PMP36010403; PMP36020401; PMP
Unit No. (if applicable)	0
Service Name	FW
Pump Manufacturer & Model	Flowserve 12EMM or Equal

Marking notes: Y=yes, N=no, X=required, NA=not applicable, NR=not required(optional mark), Mfr Std=manufacturer's standard is acceptable.

Motor Data	Value or note	Unit of Measure
Type	Squirrel-Cage, Induction	
NEMA Classification	E	
Number of Windings	1	
Synchronous Speed	1800	rpm
Motor Shaft Type	Solid(STD)	
Motor Power Service		
Voltage	460	VAC
Phase	3	Φ
Frequency	60	Hz
Frequency range		
Speed	Variable w'variable torque	
Inverter duty motor (with inslulated bearings)	Yes	
Motor Performance		
Minimum Submergence		
Motor Horsepower	125	Hp
Energy Efficiency Rating	Premium Energy Efficiency	
Guaranteed Minimum Full Load Efficiency		%
Guaranteed Minimum Full Load Power Factor		%
Maximum Ambient Temperature	50	degree C
Service Factor @ Rated Max. Ambient Temperature	1	
Elevation above sea level	6638	Ft MSL
Motor Enclosure Data		

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Motor Enclosure Type	TEFC	
Motor Orientation	Vertical	
Insulation class	F	
NEMA Mounting Type	mfr std	
Minimum Bowl Efficiency		
Thermal Protection	Thermistor	
Space Heater (single phase, specify voltage)	N/A	
Oversize Main Terminal (conduit) Box	Yes	
Terminal Connection for Equipment Grounding Wire in each Terminal Box	X	

Minimum Bowl Efficiency	
Secondary Point @ Maximum Speed	70
Model	

Minimum Bowl Efficiency

Remarks / Special Features
1. Provide motor in accordance with NEMA MG 1 unless otherwise indicated.
2. Manufacturer: For multiple units of the same type of equipment, furnish motors and accessories of a single manufacture.
Minimum Bowl Efficiency
4. Each independent circuit to the motor shall be wired to a separate terminal juction box, except for space heaters.
5. At the design condition, the motor load shall not exceed 0.95 times the nameplate power rating.
6. Adjustable Speed Drive: See Section 26 19 23, Medium-Voltage Adjustable Frequency Drive System.

Warranty Requirements
(identify specific requirements)

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Pump Data Sheet - General Requirements

Vertical Turbine	44 42 56.03

Project name	Cutter Lateral Water Treatment Plant
Project number	682853
Owner	
Part Name	Finished Water Pumps
Equipment Tag No. (if applicable)	PMP36010401; PMP36010403; PMP36020401; PMP36020403
Unit No. (if applicable)	
Service Name	FW
Pump Manufacturer & Model	Flowserve 12EMM or Equal

Marking notes: X=required, NA=not applicable, NR=not required(optional mark), Mfr Std=manufacturer's standard is acceptable.

PROJECT REQUIREMENTS		
Pumped Liquid Properties	Value or note	Unit of Measure
Pumped Liquid	Finished Water (FW)	----
Maximum Pumping Temperature	72	degree F
Minimum Pumping Temperature	39	degree F
Specific Gravity @ Min Temp	1	
Vapor Pressure @ Max Temp	0.39	psia
Viscosity @ Min Temp	1.794	cP
pH Range	6.5-7.5	----
Ambient Temperature Range (Min-Max)	-10-110	degree F
Pump Centerline Location (above MSL)	6637	ft MSL
Abrasives	None	
Min NPSH Available (NPSHA)	23.9	ft-abs H_2O
Pump Location Relative Humidity	3-99	%
Minimum Submergence	2.5	ft H_2O

DESIGN REQUIREMENTS		
Pump Performance	Required if noted or value entered	Unit of Measure
Design Duty Point		
Flow Rate	**810**	gpm
Total Dynamic Head	**420**	ft H_2O
Minimum Efficiency	**75**	%
Maximum NPSH Required	23	ft-abs H_2O
Speed	1770	rpm
Secondary Point		
Flow		gpm
Total Dynamic Head		ft H_2O
Minimum Bowl Efficiency		%
Maximum NPSH Required		ft-abs H_2O
Shutoff Head		ft H_2O
Adjustable Speed Performance:		
Maximum speed		--
Flow Rate		gpm
Total Dynamic Head		ft H_2O
Minimum Bowl Efficiency		%

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Secondary Point @ Maximum Speed		--
Flow		gpm
Total Dynamic Head		ft H_2O
Minimum Bowl Efficiency		%
Shutoff Head		ft H_2O
Minimum Speed		--
Flow Rate	354	gpm
Total Dynamic Head	388	ft H_2O
Minimum Bowl Efficiency		%
Secondary Point @ Minimum Speed		--
Flow		gpm
Total Dynamic Head		ft H_2O
Minimum Efficiency		%
Shutoff Head		ft H_2O

Minimum Moment of Inertia	Required if value entered	Unit of Measure
Pump		$ft\text{-}lb^2$
Motor		$ft\text{-}lb^2$

Pump Configuration	Required if noted or value entered	Unit of Measure
Baseplate & Frame	Mfr Std	
Drive/Pump Coupling Type	**Mfr Standard**	
Number of Impeller Stages	**6**	
Bowl Assembly	**Flanged**	
Impeller Rotation as Viewed From Driver End	**Counterclockwise**	
Lineshaft	**Open**	
Maximum Lineshaft Section Length	**10**	ft
Lineshaft Connection Method	**Threaded**	
Maximum Lineshaft Bearing Span	**10**	ft
Coloumn Assembly Method	**Flanged**	
Seal type - Mechanical	**NA**	
Seal type - Packing	**X**	
Seal Lubrication	**NA**	
Bearing Lubrication	**Internal Fluid**	
DIMENSION AND SIZES		
Pump Discharge	**----**	
Discharge Nozzle Nominal Size	**6**	inches
Discharge Nozzle, Plain End withThrust Tie Legs	**NR**	
Discharge Flange Size	**6**	inches
Discharge Flange Rating, ANSI B16.1	**250**	

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Pump Suction	----	
Suction Can, Nominal Diameter	**NA**	inches
Suction Can Flange Rating, ANSI B16.1	**NA**	
Suction Can, Bottom Elevation	**NA**	ft
Suction Can Nozzle, Centerline Elevation	**NA**	ft
Column Piping Length	**As Required**	ft
Discharge Head, Centerline Elevation	**6637**	ft
Sump Floor Elevation	**6615**	ft
Bottom of Sole Plate Elevation	**As Required**	ft
Bowl Diameter	**Mfr Std**	inches
Suction Bell Diameter	**Mfr Std**	inches
PUMP DRIVER		
Driver	**Motor**	
ACCESSORIES		
Coupling Guard	**X**	
Sole Plate	**X**	
Seal Water Set	**NR**	
Bearing Lubricator	**NR**	
Enclosed Lineshaft Bearing Oil Lubrication	**NR**	
Suction Bell Strainer	**X**	
FACTORY FINISHING		
Prepare, and prime, and finish coat in accordance with Section 09 90 00, Painting	**NR**	
FACTORY TESTING		
Shop Performance Test	**X**	
Owner/Design-Builder Witnessed	**X**	
FIELD TESTING		
Functional Test	**X**	
Field Acceptance Test	**X**	
Field Installation Certification	**X**	
ANALYSIS REQUIREMENTS		
Lateral Vibration Analysis	**NR**	
Torsional Vibration Analysis	**NR**	
Reverse Runaway Speed Analysis	**NR**	

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Remarks / Special Features
There shall not be any flow gaps when transitioning from 1 duty pump to 2

Special Warranty Requirements
(Identify specific requirements)

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Pump Data Sheet - Material Requirements

Vertical Turbine 44 54 56.03

Project name	Cutter Lateral Water Treatment Plant
Project number	682853
Owner	0
Part Name	Finished Water Pumps
Equipment Tag No. (if applicable)	PMP36010401; PMP36010403; PMP36020401; PMP36020403
Unit No. (if applicable)	0
Service Name	FW
Pump Manufacturer & Model	Flowserve 12EMM or Equal

Materials of Construction

General Material Requirement	◉ **Bronze Trimmed Iron** ○ **Zincless Bronze Trimmed Iron**

PUMP ASSEMBLY COMPONENTS

PART	Alternate Material Required	MATERIAL	Reference Standard
Impeller	☑	316LSS	
Shaft, pump	☑	Stainless Steel	ASTM No. A582-416
Bearings, Pump & Bowl	☑	Thordon SXL	
Casing, Pump & Bowl	☑	316LSS	
Lineshaft	☑	316LSS	
Bearing, Lineshaft[1]	☑	Rubber Buna-N	
Sleeve, Lineshaft	☐	Stainless Steel	ASTM No. A582-416
Retainer, Bearing	☐	Bronze	ASTM No. B854 C83600
Enclosing Tube	☐	Steel	ASTM No. A120, Schedule 80
Column, Pump	☐	Steel	ASTM No. A53
Suction Bell	☑	Cast Iron	ASTM No. A48 CL30
Deflector	☐	Neoprene	Commercial
Discharge Head	☐	Cast Iron	ASTM No. A48 CL30
Base Plate (option 1)	☐	Cast Iron	ASTM No. A48 CL30
Base Plate (option2)	☐	Steel	ASTM No. A36
Stuffing Box	☐	Cast Iron	ASTM No. A48 CL30

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Bushing, Stuffing Box	☐	Bronze	ASTM No. B854 C83600
Gland	☐	Bronze	ASTM No. B148 HT
Gland Studs	☐	Stainless Steel	ASTM No. A582-303
Ring, Lantern	☐	Virgin Teflon	Commercial
Grease Fitting	☐	Mfr Std	Commercial

Remarks / Special features / Spare Parts

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Pump Data Sheet - Motor Requirements	
Vertical Turbine	**44 42 56.03**

Project name	Cutter Lateral Water Treatment Plant
Project number	682853
Owner	0
Part Name	Finished Water Pumps
Equipment Tag No. (if applicable)	PMP36010401; PMP36010403; PMP36020401; PMP
Unit No. (if applicable)	0
Service Name	FW
Pump Manufacturer & Model	Flowserve 12EMM or Equal

Marking notes: Y=yes, N=no, X=required, NA=not applicable, NR=not required(optional mark), Mfr Std=manufacturer's standard is acceptable.

Motor Data	Value or note	Unit of Measure
Type	Squirrel-Cage, Induction	
NEMA Classification	E	
Number of Windings	1	
Synchronous Speed	1800	rpm
Motor Shaft Type	Solid(STD)	
Motor Power Service		
Voltage	460	VAC
Phase	3	Φ
Frequency	60	Hz
Frequency range		
Speed	Variable w'variable torque	
Inverter duty motor (with inslulated bearings)	Yes	
Motor Performance		
Minimum Submergence		
Motor Horsepower	125	Hp
Energy Efficiency Rating	Premium Energy Efficiency	
Guaranteed Minimum Full Load Efficiency		%
Guaranteed Minimum Full Load Power Factor		%
Maximum Ambient Temperature	50	degree C
Service Factor @ Rated Max. Ambient Temperature	1	
Elevation above sea level	6638	Ft MSL
Motor Enclosure Data		

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Motor Enclosure Type	TEFC	
Motor Orientation	Vertical	
Insulation class	F	
NEMA Mounting Type	mfr std	
Minimum Bowl Efficiency		
Thermal Protection	Thermistor	
Space Heater (single phase, specify voltage)	N/A	
Oversize Main Terminal (conduit) Box	Yes	
Terminal Connection for Equipment Grounding Wire in each Terminal Box	X	

Minimum Bowl Efficiency	
Secondary Point @ Maximum Speed	70
Model	

Minimum Bowl Efficiency

Remarks / Special Features
1. Provide motor in accordance with NEMA MG 1 unless otherwise indicated.
2. Manufacturer: For multiple units of the same type of equipment, furnish motors and accessories of a single manufacture.
Minimum Bowl Efficiency
4. Each independent circuit to the motor shall be wired to a separate terminal juction box, except for space heaters.
5. At the design condition, the motor load shall not exceed 0.95 times the nameplate power rating.
6. Adjustable Speed Drive: See Section 26 19 23, Medium-Voltage Adjustable Frequency Drive System.

Warranty Requirements
(identify specific requirements)

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SECTION 44 42 56.04
SUBMERSIBLE PUMPS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards that may be referenced in this section:

1. American Bearing Manufacturers Association (ABMA):
   a. 9, Load Ratings and Fatigue Life for Ball Bearings.
   b. 11, Load Rating and Fatigue Life for Roller Bearings.
2. American Society of Mechanical Engineers (ASME): B16.1, Gray Iron Pipe Flanges and Flanged Fittings, Class 25, 125, and 150.
3. ASTM International (ASTM):
   a. A48, Standard Specification for Gray Iron Castings.
   b. A576, Standard Specification for Steel Bars, Carbon, Hot-Wrought, Special Quality.
4. Hydraulic Institute Standards (HIS):
   a. 11.6, Submersible Pump Test.
   b. 14.6, Rotodynamic Pumps for Hydraulic Performance Acceptance Tests.
5. National Electrical Manufacturers Association (NEMA).
6. National Fire Protection Association (NFPA):
   a. 70, National Electrical Code.
   b. 497, Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas.
7. Underwriters Laboratories Inc. (UL).

1.02 DEFINITIONS

A. Terminology pertaining to pumping unit performance and construction shall conform to ratings and nomenclature of Hydraulic Institute Standards.

1.03 SUBMITTALS

A. Action Submittals:

1. Make, model, weight, and horsepower of each equipment assembly.
2. Complete catalog information, descriptive literature, specifications, and identification of materials of construction, including cable seal details.
3. Performance data curves showing head, capacity, horsepower demand, and pump efficiency over entire operating range of pump, from shutoff to maximum capacity. Indicate separately head, capacity, horsepower

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demand, overall efficiency, and minimum submergence required at guarantee point.

4. For variable speed motors, provide variable speed curves for every 50 rpm over the operational range.
5. Power and control wiring diagrams, including terminals and numbers.
6. Motor data, in accordance with the requirements of Section 26 20 00, Low-Voltage AC Induction Motors.
7. Adjustable frequency drive data, in accordance with the requirements of Section 26 29 23, Low-Voltage Adjustable Frequency Drive System.
8. Factory-finish system.
9. L-10 bearing life calculations per ABMA.
10. If required, wiring for motor protection module.
11. Seismic anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Seismic Anchorage and Bracing.

B. Informational Submittals:

1. Seismic anchorage and bracing calculations as required by Section 01 88 15, Seismic Anchorage and Bracing.
2. Special shipping, storage and protection, and handling instructions.
3. Manufacturer's printed installation instructions.
4. Factory and Field Performance Test Reports.
5. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements, that factory finish system meets requirements specified herein.
6. Suggested spare parts list to maintain equipment in service for period of 1 year and 5 years. Include list of special tools required for checking, testing, parts replacement, and maintenance with current price information.
7. List special tools, materials, and supplies furnished with equipment for use prior to and during startup and for future maintenance.
8. Operation and Maintenance Data as specified in Section 01 78 23, Operation and Maintenance Data.
9. Manufacturer's Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers' Field Services.

1.04 EXTRA MATERIALS

A. Furnish for each set of pumps:

1. One set mechanical seals.
2. One complete set of special tools required to dismantle pump.

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PART 2 PRODUCTS

2.01 GENERAL

A. Submersible, vertical shaft, centrifugal non-clog type, for pumping wastewater.

B. Designed for continuous operation under submerged or partially submerged conditions, and intermittent operation when totally dry without damage to pump or motor.

C. Where adjustable speed drives are required, furnish a coordinated operating system complete with pump, drive, and speed controller.

D. Pumps furnished under this section to be provided by a single manufacturer.

2.02 SUPPLEMENTS

A. Specific pump requirements are attached to this section as supplements.

2.03 COMPONENTS

A. Equipment consists of pump complete with motor, control system, guide rail, anchoring brackets, base elbow, power cable, pump lifting cable, control panel and level switches.

B. Characteristics:

1. Motor and rotating parts shall be removable from motor end of pump.
2. Mating surfaces to be watertight and fitted with nitrile O-rings.
3. Pumps fitted with dynamically balanced nonclog impellers designed to pass course solids and stringy materials.

C. Lifting Arrangement:

1. Stainless steel chain, 2 feet minimum, and one “grip-eye.”
2. Attach chain permanently to pump and access platform with stainless steel wire rope.
3. “Grip-eye” capable of being threaded over and engaging links of stainless steel chain so pump and motor may be lifted with “grip-eye” and independent hoist.

D. Sliding Guide Bracket:

1. Integral part of pump unit.
2. Pump unit to be guided by no less than two guide bars, or equivalent cable system, and pressed tightly against discharge connection elbow

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with metal-to-metal contact or through use of profile-type gasket, provided gasket is attached to pump's flange and can be easily accessed for inspection when pump is lifted out of wet well.

3. Pump metal parts that contact guide rail or cable system shall be made of nonsparking materials.

E. Oil chamber between seals shall be equipped with drain and inspection plug. Plug shall have positive antileak seal and shall be easily accessible from outside.

F. Motor nameplate horsepower not to be exceeded at head-capacity point on pump curve.

G. Pump motor and sensor cables shall be suitable for submersible pump application and cable sizing shall conform to NFPA 70 specifications for pump motors. Cables shall be of sufficient length to reach junction boxes without strain or splicing.

H. Motor Protection Module: If required, provide pump with a motor protection module for remote mounting. Contract Drawings are based on first named submersible pump manufacturer and motor protection module. If pump and motor protection module other than first named manufacturer is provided, provide revised wiring for the motor protection module.

I. Cable Entry System:

1. Junction chamber and motor separated by stator lead sealing gland or terminal board that prevents foreign material entering through pump top.
2. Utilize cable with factory-installed sealing gland with nonshrink epoxy seal system.
3. O-ring compression seal between sealing gland and cable entry point shall also be acceptable.

2.04 CONTROL PANEL

A. NEMA 4X enclosure, for outdoor duty.

B. Refer to Section 40 90 11, Instruments and Panels Subsystem (IPS), for additional panel requirements.

C. Free standing, post mounted.

D. Features:

1. Main circuit breaker disconnect interlocked with panel door.
2. Combination circuit breaker type, NEMA rated motor starters.

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3. Fused control power transformer, 120V ac.
4. Alternator and pump lead-lag controls.
5. ON/OFF/AUTO switches.
6. Running lights.
7. High level indication.
8. Normally closed, dry, 5 amps at 120V ac contacts for remote indication of:
    a. High level alarm.
    b. Pump failure (temperature or moisture alarm).
9. Terminal strip for interfacing with external wiring.
10. High temperature indication.
11. Moisture alarm indication.
12. Alarm (high temperature, moisture, or high level) beacon located on top of panel.
13. Lightning protection.
14. Intrinsically safe relays as required for UL validation.
15. Alarm silence button.
16. Document pocket located inside panel with pump and panel operation and maintenance manual, and separate laminated pump curve.
17. 110-volt, duplex GFI outlet, weather-protected, and accessible from outside of panel.
18. Run hour meter.
19. 100 watts minimum, condensation heater with thermostat.
20. UL listing mark.

E. Prewired and factory tested.

F. Mount control switches, indicating lights, and switches on hinged front panel.

G. Single Feed: 480 volts, three-phase.

2.05 ACCESSORIES

A. Level Switches: In accordance with Section 40 90 11, Instruments and Panels Subsystem (IPS), component L8 and for:

1. Low Low Level: Pumps off.
2. Low Level: First pump on.
3. High Level: Second pump on.
4. High High Level: Alarm.

B. Equipment Identification Plate: 16-gauge stainless steel with 1/4-inch die-stamped equipment tag number securely mounted in readily visible location.

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C. Anchor Bolts: Type 316 stainless steel, sized by equipment manufacturer, and as specified in Section 05 50 00, Metal Fabrications. Coat in accordance with Section 09 90 00, Painting and Coating.

2.06 FACTORY FINISHING

A. Prepare, prime, and finish coat in accordance with Section 09 90 00, Painting and Coating.

B. Manufacturer's standard epoxy system for continuous submergence in corrosive water.

2.07 SOURCE QUALITY CONTROL

A. Control Panel:

1. Factory Inspections: Inspect control panels for required construction, electrical connection, and intended function.
2. Factory Tests and Adjustments: Test all control panels actually furnished.

B. Pump:

1. Factory Performance Test:
   a. In accordance with HIS 11.6, Grade 1B for submersible pump tests.
   b. Include test data sheets, curve test results, and performance test logs.
2. Conduct on each pump.
3. Perform under actual or approved simulated operating conditions.
   a. Throttle discharge valve to obtain pump data points on curve at 2/3, 1/3, and shutoff conditions.

C. Submersible Motor Functional Test: In accordance with HIS 11.6.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer's printed instructions.

B. Mount the discharge elbow to the floor of the wetwell floor with stainless steel bolts.

C. Connect piping without imposing strain to flanges.

D. No portion of pump shall bear directly on floor of sump.

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3.02 FIELD FINISHING

A. Equipment as specified in Section 09 90 00, Painting and Coating.

3.03 FIELD QUALITY CONTROL

A. Functional Test: Conduct on each pump.

1. Alignment: Test complete assemblies for correct rotation, proper alignment and connection, and quiet operation.
2. Flow Output: Measured by plant instrumentation and storage volumes.
3. Operating Temperatures: Monitor bearing areas on pump and motor for abnormally high temperatures.
4. Test for continuous 3-hour period.
5. Test Report Requirements: In accordance with Hydraulic Institute Standards for submersible pump tests HIS 14.6 and 11.6.

B. Pump Test:

1. General:
   a. Conduct on each pump provided.
   b. Conduct in accordance with HIS 11.6.
2. Routine Production Tests:
   a. Check impeller, motor rating and electrical connections for compliance to specification.
   b. Test motor and cable insulation for moisture content and insulation defects.
   c. Prior to submergence, run pump dry to establish correct rotation and mechanical integrity.
   d. Conduct abbreviated three-point operational performance test.
   e. After operational performance test, perform insulation test again.

3.04 MANUFACTURER'S SERVICES

A. Manufacturer's Representative: Present at Site or classroom designated by **[A: Owner,] [B: ,]** for minimum person-days listed below, travel time excluded:

1. **[C:]** person-days for **[D: installation assistance] [E: and] [F: inspection].**
2. **[G:]** person-days for **[H: functional] [I: and] [J: performance]** testing and completion of Manufacturer's Certificate of Proper Installation.
3. **[K:]** person-days for prestartup classroom or Site training.
4. **[L:]** person-days for facility startup.

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5. **[M:]** person-days for post-startup **training [N: of Owner's personnel.] [O: Training shall not commence until accepted detailed lesson plan for each training activity has been reviewed by [P: Owner] [Q: Engineer] [R:].]**

B. See Section 01 43 33, Manufacturers' Field Services and Section 01 91 14, Equipment Testing and Facility Startup.

3.05 SUPPLEMENTS

A. The supplements listed below, following "End of Section," are part of this Specification.

1. Data Sheets: Pump and Motor.

END OF SECTION

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SUBMERSIBLE PUMP DATA SHEET
SLUDGE TRANSFER PUMP 1 & 2

Pump Name:	Tag Numbers:	Manufacturers:
Sludge Transfer Pump 1	PMP420-101-04	1) KSB
Sludge Transfer Pump 2	PMP420-201-04	2) Flygt
		3) Flowserve
		4) Or Equal

SERVICE CONDITIONS

Liquid Pumped: Sludge
Soilds Content: Less than 2.0%
Maximum Solid Diameter: 1"

Pumping Temperature (Fahrenheit):
Normal: 50
Max: 68
Min: 39

Specific Gravity @ 60 Degrees F: 1
Vapor Pressure @ 60 Degrees F:
Viscosity Range: 1 cP
Liquid pH: 6.5-8.0
Abrasive (Y/N): No
Possible Scale Buildup (Y/N): No
Maximum Total Suspended Solids: 20,000 mg/L
Altitude (ft msl): 6,600
Area Classification: Non-Hazardous
Location (indoor/outdoor): Outdoor
Installation Type: Wet-well, Submerged
Min. NPSH Available (Ft. Absolute): 4

PERFORMANCE REQUIREMENTS AT PRIMARY DESIGN POINT

Duty Point 1

Rated Capacity:	411	gpm
Total Dynamic Head Rated:	41.5	feet
Maximum Shutoff Pressure:	77	feet
Min. Rated Pump Efficiency at Rated Capacity:	60	%
Max. Pump Speed at Rated Capacity:	1,800	rpm
Adjustable or Constant Speed:	Adjustable	

Duty Point 2

Rated Capacity:	315	gpm
Total Dynamic Head Rated:	37.7	feet
Maximum Shutoff Pressure:	59	feet
Min. Rated Pump Efficiency at Rated Capacity:	60	%
Max. Pump Speed at Rated Capacity:	1,800	rpm
Adjustable or Constant Speed:	Adjustable	

Duty Point 3

Rated Capacity:	212	gpm
Total Dynamic Head Rated:	34.6	feet
Maximum Shutoff Pressure:	49	feet
Min. Rated Pump Efficiency at Rated Capacity:	60	%
Max. Pump Speed at Rated Capacity:	1,800	rpm
Adjustable or Constant Speed:	Adjustable	

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SUBMERSIBLE PUMP DATA SHEET
SLUDGE TRANSFER PUMP 1 & 2

DESIGN AND MATERIALS

Pump Type:	Heavy-Duty Nonclog	**Elastomers:**	Nitrile Rubber
Volute Material:	Cast Iron ASTM A48	**Fasteners:**	Stainless Steel
Pump Casing Material:	Cast Iron ASTM A48	**Impeller:**	Single Vane, Radial Flow
Motor Housing Material:	Cast Iron ASTM A48	**Material:**	Cast Iron ASTM A48
Wear Rings Case:	Yes	**Shaft:**	Stainless Steel
Material:	Cast Iron ASTM A48	**Base Elbow:**	Cast Iron ASTM A48
Wear Ring Impeller:	No	**Flange Class:**	ANSI 125#
Material:	N/A	**Flange Size:**	4"
Coupling:	MFG Standard		
Double Mechanical Seal:	Yes		

DRIVE MOTOR (See Section 26 20 00, Low Voltage AC Induction Motors.)

Motor Size (HP): 10 **Voltage:** 460 **Phase:** 3
Frequency (Hz): 60 **Synchronous Speed (rpm):** 1800
Service Factor: 1.15 **Inverter Duty:** Y **Enclosure:** TEFC
Enclosure: Submersible
Moisture Detection Switches (Y/N): Yes
Thermal Protection Embedded in Windings (Y/N): Yes
Pump Speed Control: Adjustable Speed Drive
(See Section 26 29 23, Low-Voltage Adjustable Frequency Drive System.)

REMARKS

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SUBMERSIBLE PUMP DATA SHEET
SLUDGE TRANSFER PUMP 1 & 2

Pump Name:	Tag Numbers:	Manufacturers:
Environmental Discharge/Recycle Pump 1	PMP460-100-01	1) KSB
Environmental Discharge/Recycle Pump 2	PMP460-100-02	2) Flygt
Environmental Discharge/Recycle Pump 3	PMP460-100-03	3) Flowserve
		4) Or Equal

SERVICE CONDITIONS

Liquid Pumped: Water
Soilds Content: Less than 2.0%
Maximum Solid Diameter: 1"

Pumping Temperature (Fahrenheit):
Normal: 50
Max: 68
Min: 39

Specific Gravity @ 60 Degrees F: 1
Vapor Pressure @ 60 Degrees F:
Viscosity Range: 1 cP
Liquid pH: 6.5-8.0
Abrasive (Y/N): No
Possible Scale Buildup (Y/N): No
Maximum Total Suspended Solids: 20,000 mg/L
Altitude (ft msl): 6,600
Area Classification: Non-Hazardous
Location (indoor/outdoor): Outdoor
Installation Type: Wet-well, Submerged
Min. NPSH Available (Ft. Absolute):

PERFORMANCE REQUIREMENTS AT PRIMARY DESIGN POINT

Duty Point 1

Rated Capacity:	125 gpm
Total Dynamic Head Rated:	52 feet
Maximum Shutoff Pressure:	63 feet
Min. Rated Pump Efficiency at Rated Capacity:	50 %
Max. Pump Speed at Rated Capacity:	1,800 rpm
Adjustable or Constant Speed:	Adjustable

Duty Point 2

Rated Capacity:	35 gpm
Total Dynamic Head Rated:	47 feet
Maximum Shutoff Pressure:	49 feet
Min. Rated Pump Efficiency at Rated Capacity:	28 %
Max. Pump Speed at Rated Capacity:	1,800 rpm
Adjustable or Constant Speed:	Adjustable

Duty Point 3

Rated Capacity:	20 gpm
Total Dynamic Head Rated:	47 feet
Maximum Shutoff Pressure:	48 feet
Min. Rated Pump Efficiency at Rated Capacity:	16 %
Max. Pump Speed at Rated Capacity:	1,800 rpm
Adjustable or Constant Speed:	Adjustable

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SUBMERSIBLE PUMP DATA SHEET
SLUDGE TRANSFER PUMP 1 & 2

DESIGN AND MATERIALS

Pump Type:	Heavy-Duty Nonclog	**Elastomers:**	Nitrile Rubber
Volute Material:	Cast Iron ASTM A48	**Fasteners:**	Stainless Steel
Pump Casing Material:	Cast Iron ASTM A48	**Impeller:**	Free Flow (vortex) Impeller
Motor Housing Material:	Cast Iron ASTM A48	**Material:**	Cast Iron ASTM A48
Wear Rings Case:	Yes	**Shaft:**	Stainless Steel
Material:	Cast Iron ASTM A48	**Base Elbow:**	Cast Iron ASTM A48
Wear Ring Impeller:	No	**Flange Class:**	ANSI 125#
Material:	N/A	**Flange Size:**	3"
Coupling:	MFG Standard		
Double Mechanical Seal:	Yes		

DRIVE MOTOR (See Section 26 20 00, Low Voltage AC Induction Motors.)

Motor Size (HP): 5 **Voltage:** 460 **Phase:** 3
Frequency (Hz): 60 **Synchronous Speed (rpm):** 1800
Service Factor: 1.15 **Inverter Duty:** Y **Enclosure:** TEFC
Enclosure: Submersible
Moisture Detection Switches (Y/N): Yes
Thermal Protection Embedded in Windings (Y/N): Yes
Pump Speed Control: Adjustable Speed Drive
(See Section 26 29 23, Low-Voltage Adjustable Frequency Drive System.)

REMARKS

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SECTION 44 42 56.11
VERTICAL INLINE BOOSTER PUMP PACKAGE

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Bearing Manufacturers' Association (ABMA).
2. Hydraulic Institute Standards.
3. National Electrical Manufacturer's Association (NEMA): MG 1, Motors and Generators.
4. Occupational Safety and Health Administration (OSHA).

1.02 DEFINITIONS

A. Terminology pertaining to pumping unit performance and construction shall conform to the ratings and nomenclature of the Hydraulic Institute Standards.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Make, model, weight, and horsepower of each equipment assembly.
   b. Complete catalog information, descriptive literature, specifications, and identification of materials of construction.
   c. Performance data curves showing head, capacity, horsepower demand, and pump efficiency over entire operating range of pump from shutoff to maximum capacity. Indicate separately the head, capacity, horsepower demand, overall efficiency, and minimum submergence required at guarantee point.
   d. Detailed structural, mechanical, and electrical drawings showing equipment dimensions, size, and locations of connections and weights of associated equipment.
   e. Power and control wiring diagrams, including terminals and numbers.
   f. Complete motor nameplate data, as defined by NEMA, motor manufacturer.
   g. Factory finish system data sheets.
   h. Seismic anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.

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B. Informational Submittals:

1. Seismic anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
2. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements, that factory finish system is identical to the requirements specified herein.
3. Special shipping, storage and protection, and handling instructions.
4. Manufacturer's printed installation instructions.
5. Suggested spare parts list to maintain the equipment in service for a period of 1 year and 5 years. Include a list of special tools required for checking, testing, parts replacement, and maintenance with current price information.
6. List special tools, materials, and supplies furnished with equipment for use prior to and during startup and for future maintenance.
7. Operation and Maintenance Data: As specified in Section 01 78 23, Operation and Maintenance Data.
8. Manufacturer's Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers' Field Services.

1.04 EXTRA MATERIALS

A. Furnish for this set of pumps:

1. Complete set packing.
2. Complete set bearings.
3. Complete set gaskets and O-ring seals.
4. Complete set of shaft sleeves.
5. Complete set keys, dowels, pins, etc.
6. Complete mechanical seal.
7. Impeller.
8. Impeller shaft.
9. Impeller wear ring.
10. Head shaft.
11. One complete set of special tools required to dismantle pump.

PART 2 PRODUCTS

2.01 GENERAL

A. Coordinate pump requirements with drive manufacturer and be responsible for pump and drive requirements.

B. Where adjustable speed drives are required, furnish a coordinated operating system complete with pump, drive, and speed controller.

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2.02 SUPPLEMENTS

A. Some specific requirements are attached to this section as supplements.

2.03 PUMPS

A. All pumps shall be ANSI NSF 61 / NSF372 Listed for drinking water and low lead requirements.

B. Pumps shall be of the in-line vertical multi-stage design.

C. The suction/discharge base shall have ANSI Class 125 or Class 250 flange connections in a slip ring (rotating flange) design as indicated in the drawings or pump schedule.

2.04 VARIABLE FREQUENCY DRIVE

A. Each motor shall have a dedicated Variable Frequency Drive (VFD) or shall be of the integrated Variable Frequency Drive design.

2.05 PUMP SYSTEM CONTROLLER

A. Pump system controller shall be developed and supported by the pump manufacturer.

B. Pump system control panel shall have ethernet connectivity.

2.06 PUMP SKID

A. Pumps, motors, VFDs, and control panel shall be provided as a single skidded system.

B. Skid Dimensions shall not exceed:

1. 108 inches in length.
2. 72 inches in width.
3. 78 inches in height.

C. Discharge and suction piping configuration shall conform to the configuration shown on the drawings and P&IDs.

2.07 ACCESSORIES

A. Equipment Identification Plate: 16-gauge stainless steel with 1/4-inch die-stamped equipment tag number securely mounted in a readily visible location.

B. Lifting Lugs: Equipment weighing over 100 pounds.

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C. OSHA-approved coupling guard for direct coupled or belt driven pumps.

D. Anchor Bolts: Type 316 stainless steel, sized by equipment manufacturer, and as specified in Section 05 50 00, Metal Fabrications. Coat in accordance with Section 09 90 00, Painting and Coating.

2.08 FACTORY FINISHING

A. Manufacturer's standard baked enamel finish.

2.09 SOURCE QUALITY CONTROL

A. Factory Inspections: Inspect control panels for required construction, electrical connection, and intended function.

B. Factory Tests and Adjustments: Test all equipment and control panels actually furnished.

C. Factory Test Report: Include test data sheets, curve test results.

D. Functional Test: Perform manufacturer's standard test on equipment.

E. Performance Test:

1. In accordance with Hydraulic Institute Standards.
2. Adjust, realign, or modify units and retest in accordance with Hydraulic Institute Standards if necessary.

F. Motor Test: See Section 26 20 00, Low-Voltage AC Induction Motors.

G. Hydrostatic Tests: Pump casing(s) tested at 150 percent of shutoff head. Test pressure maintained for not less than 5 minutes.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer's printed instructions.

B. Level base by means of steel wedges (steel plates and steel shims). Wedge taper not greater than 1/4 inch per foot. Use double wedges to provide a level bearing surface for pump and driver base. Accomplish wedging so there is no change of level or springing of baseplate when anchor bolts are tightened.

C. Adjust pump assemblies such that the driving units are properly aligned, plumb, and level with the driven units and all interconnecting shafts and couplings. Do not compensate for misalignment by use of flexible couplings.

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D. After pump and driver have been set in position, aligned, and shimmed to proper elevation, grout the space between the bottom of the baseplate and the concrete foundation with a poured, nonshrinking grout of the proper category, as specified in Section 03 62 00, Nonshrink Grouting. Remove wedges after grout is set and pack void with grout.

E. Connect suction and discharge piping without imposing strain to pump flanges.

F. Anchor Bolts: Accurately place using equipment templates and as specified in Section 05 50 00, Metal Fabrications.

3.02 FIELD FINISHING

A. Finish equipment as specified in Section 09 90 00, Painting and Coating.

3.03 FIELD QUALITY CONTROL

A. Functional Tests: Conduct on each pump.

1. Alignment: Test complete assemblies for correct rotation, proper alignment and connection, and quiet operation.
2. Flow Output: Measured by plant instrumentation and storage volumes.

B. Performance Test:

1. Conduct on each pump.
2. Perform under simulated operating conditions.
3. Test for a continuous 3-hour period without malfunction.
4. Test Log: Record the following:
   a. Total head.
   b. Capacity.
   c. Horsepower requirements.
   d. Flow measured by factory instrumentation and storage volumes.
   e. Pump discharge pressure converted to feet of liquid pumped and corrected to pump discharge centerline.
   f. Field head.
   g. Driving motor voltage and amperage measured for each phase.

3.04 MANUFACTURER'S SERVICES

A. Manufacturer's Representative: Present at Site or classroom designated by **[A: Owner,] [B: ,]** for minimum person-days listed below, travel time excluded:

1. **[C:]** person-days for **[D: installation assistance] [E: and] [F: inspection].**

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2. **[G:]** person-days for **[H: functional] [I: and] [J: performance]** testing and completion of Manufacturer's Certificate of Proper Installation.
3. **[K:]** person-days for prestartup classroom or Site training.
4. **[L:]** person-days for facility startup.
   [M:] person-days for post-startup training **[N: of Owner's personnel]. [O: Training shall not commence until an accepted detailed lesson plan for each training activity has been reviewed by [P: Owner] [Q: Engineer] [R:].]**

B. See **[A: Section 01 43 33, Manufacturers' Field Services] [B: and] [C: Section 01 91 14, Equipment Testing and Facility Startup.]**

3.05 SUPPLEMENTS

A. The supplements listed below, following "End of Section," are a part of this Specification.

1. Pump Data Sheet.

END OF SECTION

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VERTICAL INLINE BOOSTER PUMP PACKAGE DATA SHEET

Tag Numbers: PMP-300-301-01, 02 & 03

Pump Name: GAC Supply Pump 1, 2 & 3

Manufacturer and Model Number: (1) Grundfos, Hydro MPC-E
(2) Or approved equal

SERVICE CONDITIONS

Liquid Pumped (Material and Percent): Water

Pumping Temperature (Fahrenheit): Normal: _____ Max _____ Min _____

Specific Gravity at 60 Degrees F: 1.0 Viscosity Range: _____

Abrasive (Y/N) N Possible Scale Buildup (Y/N): N

Min. NPSH Available (Ft. Absolute): _____

Suction Pressure (Ft): Max 5 Rated _____

PERFORMANCE REQUIREMENTS AT PRIMARY DESIGN POINT

Capacity (US gpm): Rated: 350

Total Dynamic Head (Ft): Rated: 35

Min. Hydraulic Efficiency (%): 70%

Maximum Shutoff Pressure (Ft): _____

Max. Pump Speed at Design Point (rpm): _____

Constant (Y/N): N Adjustable (Y/N): Y

PERFORMANCE REQUIREMENTS AT 50 PERCENT RATED SPEED

Capacity (US gpm): 170

Total Dynamic Head (Ft): 35

DESIGN AND MATERIALS

ANSI (Y/N) _____ Standard (Y/N) Y Design: Frame-mounted (Y/N) Y
Close-Coupled Casing (Y/N) ___ Back Pullout (Y/N) _____

Discharge Orientation: Vertical Rotation (view from end coupling): _____

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Casing Materials: _____

Case Wear Ring (Y/N) _____ Material: _____

Impeller: Type: _____ Material: _____

Impeller Wear Ring (Y/N): _____ Material: _____

Shaft Material: _____ Shaft Sleeve Material: _____

Shaft Seal: _____ Packing (Y/N) _____ Material: _____

Mechanical (Y/N) _____ Type: _____

Lubrication: _____

ABMA L-10 Bearing Life (Hrs): _____ Lubrication: _____

Coupling: _____ Falk (Y/N) _____ Fast (Y/N) _____
Spring-Grid (Y/N) _____

Gear Type (Y/N) _____ Spacer (Y/N) _____ Manufacturer _____
Standard (Y/N) _____

Baseplate: Design: _____ Material: _____

Drive Type: Direct-Coupled: _____ Belt _____ Adjustable Speed _____

Other: _____

Adjustable Speed Drive Range: ____ min to ____ max, See Section 26 29 23, Low Voltage Adjustable Frequency Drive System.

DRIVE MOTOR (See Section 26 20 00, Low-Voltage AC Induction Motors.

Horsepower: 10 Voltage: 460 Phase: 3 Synchronous Speed (rpm): _____

Service Factor: 1.0 Inverter Duty (Y/N) Y

Motor nameplate horsepower shall not be exceeded at any head-capacity point on the pump curve.

Enclosure: DIP ____ EXP ____ ODP ____ TEFC ____ CISD-TEFC ____
TENV ____ WPI ____ WPII ____ SUBM ____

Mounting Type: Horizontal _____ Nonreverse Ratchet (Y/N) _____

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REMARKS _____

_____

_____

_____

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SECTION 44 42 56.16
PERISTALTIC HOSE PUMP

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Bearing Manufacturers Association (ABMA).
2. American Gear Manufacturers Association (AGMA).
3. American National Standards Institute (ANSI).
4. ASTM International (ASTM): A48/A48M, Standard Specification for Gray Iron Castings.
5. Hydraulic Institute Standards.
6. National Electrical Manufacturer's Association (NEMA): MG 1, Motors and Generators.

1.02 DEFINITIONS

A. Terminology pertaining to pumping unit performance and construction conforms to the ratings and nomenclature of the Hydraulic Institute Standards.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Complete catalog information, descriptive literature, specifications, and identification of materials of construction.
   b. Detailed mechanical and electrical drawings showing equipment dimensions, size, and locations of connections and weights of associated equipment.
   c. Make, model, weight, and horsepower of each equipment assembly.
   d. Performance data curves showing head, capacity, and horsepower demand over entire operating range of pump, from shutoff to maximum capacity. Indicate head, capacity, and horsepower demand required at guarantee point.
   e. Complete motor nameplate data, as defined by NEMA, motor manufacturer, and including any motor modifications.
   f. Control panel elevation drawings showing construction and placement of operator interface devices and other elements.
   g. Power and control wiring diagrams, including terminals and numbers.
   h. Listing of extra materials supplied for this section.

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i. Factory finish system.
j. Seismic anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.

B. Informational Submittals:

1. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements signed by an authorized representative of manufacturer that equipment and factory-applied coating system(s) meet requirements specified herein.
2. Seismic anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
3. Factory test reports.
4. Special shipping, storage and protection, and handling instructions.
5. Manufacturer's printed installation instructions.
6. List special tools, materials, and supplies furnished with equipment for use prior to and during startup, and for future maintenance.
7. Suggested spare parts list to maintain equipment in service for a period of 1 year and 5 years. Include a list of special tools required for checking, testing, parts replacement, and maintenance with current price information.
8. Operation and Maintenance Data: As specified in Section 01 78 23, Operation and Maintenance Data.
9. Manufacturer's Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers' Field Services.

1.04 EXTRA MATERIALS

A. Furnish, tag, and box for shipment and storage the following **s**pare parts and materials:

Item	**Quantity**
Gasket Kit	One complete set per set of pumps
Hoses	One per set of pumps
Hose Lubricant Refill	One per set of pumps
[J: Bearings and Shims]	One complete set per set of pumps
[N:]	**[O: One]** complete set **[P: per pump] [Q: per set of pumps]**
[R: Special tools required to maintain or dismantle]	**[S: One]** complete set **[T: for each different size unit]**

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PART 2 PRODUCTS

2.01 GENERAL

A. Coordinate pump requirements with motor manufacturer and be responsible for pumps and motors.

B. Where adjustable speed drives are required, furnish and be responsible for a coordinated operating system complete with pump, motor, and adjustable speed drive.

C. Design Requirements: In accordance with Section 01 61 00, Common Product Requirements.

2.02 SUPPLEMENTS

A. Specific product requirements are attached to this section as supplements.

B. **[A: No "or-equal" or substitute products will be considered.]**

2.03 ACCESSORIES

A. Lifting Lugs: Provide suitably attached for equipment assemblies and components weighing over 100 pounds.

B. Equipment Identification Plates: Provide 16-gauge 316 stainless steel identification plate securely mounted on each separate equipment component **[B: and control panel]** in a readily visible location with **[C: 3/8] [D: 1/4]**-inch high **[E: engraved] [F: die-stamped]** block type **[G: black enamel filled]** equipment **[H: identification number] [I: and letters]** indicated in this Specification **[J: and as shown]**.

C. Anchor Bolts: Type 316 stainless steel, sized by equipment manufacturer, and as specified in Section 05 50 00, Metal Fabrications. Coat in accordance with Section 09 90 00, Painting and Coating.

D. Leak Detection Switch:

1. Locate near top of pump to detect leakage of pumped product into pump housing.
2. Mount sensor on rear of pump housing.
3. Supply sensor Normally Closed with ability for field adjustment to Normally Open.
4. Float Switch Rating: Vmax equals 240V ac, Imax equals 1 amp, Pmax equals 50VA.

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E. Revolution Sensor:

1. Provide inductive type revolution sensor located to detect rotor revolutions.
2. Pump manufacturer to supply and mount sensor and triggering device.
3. Inductive Sensor Rating: Vmax equals 30V dc, Imax equals 150 mA, Pmax equals 4.5 VA.

F. Inlet Pulsation Accumulators and Discharge Pulsation Dampeners:[BM1]

1. Inlet size same as pump connecting pipe size. Provide ANSI Class 150 flanged inlet.
2. Housing: **[A: Epoxy coated steel.] [B: Type 316L stainless steel.] [C: .]**
3. Bladder: **[D: Buna-N.] [E: Hypalon.] [F: .]**
4. Accessories: Pressure gauge, air fill valve, and cap.
5. Fasteners: Stainless steel.
6. Capacity: Sized by manufacturer.
7. Manufacturer and Product: Blacoh Fluid Control; Sentry Series.

G. Controls: In accordance with general control requirements and component qualities specified **[A: in Section 40 99 90, Package Control Systems] [B: below] [C:]**. Provide panels and controls as follows:

Panel No.	Name	NEMA 250 Rating	Material

1. Operator Controls and Indicators: **[A: .]**
2. External Interfaces: **[B: .]**
3. Functional Requirements: **[C: .]**
4. Power Requirements: **[D: .]**
5. Special Requirements: **[E: .]**

2.04 FACTORY FINISHING

A. Prepare, prime and finish coat in accordance with Section 09 90 00, Painting and Coating.

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2.05 SOURCE QUALITY CONTROL

A. Factory Tests:

1. Pumps: Assemble, check, and shim all pumps for the specific application prior to shipment.
2. Control Panels:
   a. Inspect **[A: control panels] [B:]** for required construction, electrical connection, and intended function.
   b. Test all control panels furnished.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer's printed instructions.

B. Level base by means of steel wedges; steel plates and steel shims.

1. Wedge taper not greater than 1/4 inch per foot.
2. Use double wedges to provide a level bearing surface for pump and driver base.
3. Accomplish wedging so there is no change of level or springing of baseplate when anchor bolts are tightened.

C. Adjust pump assemblies such that driving units are properly aligned, plumb, and level with driven units and interconnecting shafts and couplings. Do not compensate for misalignment by use of flexible couplings.

D. After pump and driver have been set in position, aligned, and shimmed to proper elevation, grout space between bottom of baseplate and concrete foundation with a poured, nonshrinking grout of the proper category, as specified in Section 03 62 00, Nonshrink Grouting. Remove wedges after grout is set and pack void with grout.

E. Connect suction and discharge piping without imposing strain to pump flanges.

F. Anchor Bolts: Accurately place using equipment templates and as specified in Section 05 50 00, Metal Fabrications.

3.02 FIELD FINISHING

A. As specified in Section 09 90 00, Painting and Coating.

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3.03 FIELD QUALITY CONTROL

A. Perform preoperational checks in accordance with manufacturer's printed instructions.

B. Functional Tests:

1. Conduct on Each Pump: Test complete assemblies for correct rotation, proper connections, and normal operational characteristics.

C. Performance Tests:

1. Conduct on Each Pump:
   a. Perform under simulated or actual operating conditions.
   b. Test for a continuous 30-minute period for each pump.
   c. Test and Test Log: Record the following:
      1) Pump suction head relative to suction flange centerline.
      2) Pump discharge head relative to pump discharge flange centerline.
      3) Pump flow using pump rpm and gallons per revolution.
      4) Pump flow using plant flowmeter instrumentation, if available.
      5) Motor voltage and amperage measured for each phase.

3.04 MANUFACTURER'S SERVICES

A. Manufacturer's Representative: Present at Site or classroom designated by Owner for minimum person-days listed below, travel time excluded:

1. **[C:]** person-days for **[D: installation assistance] [E: and] [F: inspection]**.
2. **[G:]** person-days for **[H: functional] [I: and] [J: performance]** testing and completion of Manufacturer's Certificate of Proper Installation.
3. **[K:]** person-days for prestartup classroom or Site training.
4. **[L:]** person-days for facility startup.
5. **[M:]** person-days for post-startup training **[N: of Owner's personnel]**. **[O: Training shall not commence until an accepted detailed lesson plan for each training activity has been reviewed by [P: Owner] [Q: Engineer] [R:].]**

B. See **[A: Section 01 43 33, Manufacturers' Field Services] [B: , and] [C: Section 01 91 14, Equipment Testing and Facility Startup].]**

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3.05 SUPPLEMENTS

A. The supplement listed below, following “End of Section,” is a part of this Specification:

1. Peristaltic Hose Pump Data Sheets.

END OF SECTION

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PERISTALTIC HOSE PUMP DATA SHEET 44 42 56.16-1

Tag Numbers: PMP-380-501-01, PMP-380-501-02, PMP-380-501-03

Pump Name: Ferric Chloride Metering Pump 1, Ferric Chloride Metering Pump 2, and Ferric Chloride Metering Pump 3

Manufacturer and Model Number: (1) Blue-White/ProSeries-M-3

SERVICE CONDITIONS

Liquid Pumped (Material and Percent): 40% Ferric Chloride

Pumping Temperature (Fahrenheit): Normal: _____ Max 115F Min 14F

Specific Gravity @ 60 Degrees F: _____ Viscosity Range: _____

pH: _____

Abrasive (Y/N): N Possible Scale Buildup (Y/N): N

Inlet Pressure at Pump (psig): _____

Min. Net Positive Inlet Pressure Available (psia): _____

Area Classification: _____

PERFORMANCE REQUIREMENTS

Rated Capacity (gpm): 6.9 gph Rated Differential Pressure (psi): 100

Maximum Pump Speed at Rated Condition (rpm): 125

Constant Speed (Y/N): N Adjustable Speed (Y/N): Y

Speed Range: 0.001% to 100% of Rated Speed: _____

DESIGN AND MATERIALS

Pump Type: Heavy-duty, horizontal, peristaltic hose pump

Pump Configuration: Direct or close-coupled

Pump Housing Material: 413 Aluminum (polyester powder coated), NEMA 4X (IP66)

Cover Material: Polycarbonate

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Cover Seal Material: EPDM or Buna N (NBR)

Rotor Material: Valox (PBT)

Rotor Shoes: **[A: Aluminum] [B: Stainless Steel] [C:]**

No. of Rotor Shoes (Minimum): 2

Rotor Shoe Shim Material: Type 316 stainless steel

Hose Size, Millimeters: **[A: 10] [B: 15] [C: 25] [D: 32] [E: 40] [F: 50] [G: 65] [H: 80] [I: 100]**

Maximum Number of Hose Occlusions per 100 Gallons Pumped: **[A:]**

Hose Material: PVC, Polyethylene, Norprene

Hose Pressure Rating (psig): **[A: 230] [B: 125 psig]**

Hose Inserts Material: Polypropylene

Hose Lubricant: Manufacturer's standard

Flange Rating and Material: **[A: ANSI Class 125/150] [B: Carbon steel] [C: Type 316 stainless steel] [D:]**

Bearing Housing Material: Steel

Bearing Type: Ball bearings, permanently lubricated

Bearing Life (ABMA L-10) (hrs): **[A: 100,000] [B:]**

Gear Drive: **[A: Planetary type, AGMA Class II] [B:]**

Baseplate: Steel

High Level Leak Detector (Y/N): Y

Pump Speed Sensor (Y/N): _____

Revolution Sensor (Y/N): _____

Suction Pulsation Dampener (Y/N): N

Discharge Pulsation Dampener (Y/N): N

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DRIVE MOTOR (see Section 26 20 00, Low-Voltage AC Induction Motors)

Horsepower: 0.25 Voltage: 115 Phase: 3 Synchronous Speed (rpm): 125

Service Factor: 1.0 Inverter Duty (Y/N): _____

Enclosure: DIP _____ EXP _____ ODP _____ TEFC _____ CISD-TEFC _____
TENV _____ WPI _____ WPII _____ SUBM _____

[A: Adjustable Speed Drive Range: _____ min to _____ max, see Section 26 29 23, Low-Voltage Adjustable Frequency Drive Systems]

REMARKS_____

_____

_____

_____

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PERISTALTIC HOSE PUMP DATA SHEET 44 42 56.16-2

Tag Numbers: PMP-380-405-01, PMP-380-405-02, PMP-380-405-03

Pump Name: Sulfuric Acid Feed Pump 1, Sulfuric Acid Feed Pump 2, and Sulfuric Acid Feed Pump 3

Manufacturer and Model Number: (1) Blue-White/ProSeries-M-3

SERVICE CONDITIONS

Liquid Pumped (Material and Percent): 93% Sulfuric Acid

Pumping Temperature (Fahrenheit): Normal: _____ Max 115F Min 14F

Specific Gravity @ 60 Degrees F: _____ Viscosity Range: _____

pH: _____

Abrasive (Y/N): N Possible Scale Buildup (Y/N): N

Inlet Pressure at Pump (psig): _____

Min. Net Positive Inlet Pressure Available (psia): _____

Area Classification: _____

PERFORMANCE REQUIREMENTS

Rated Capacity (gpm): 2.31 gph Rated Differential Pressure (psi): 100

Maximum Pump Speed at Rated Condition (rpm): 125

Constant Speed (Y/N): N Adjustable Speed (Y/N): Y

Speed Range: 0.001% to 100% of Rated Speed: _____

DESIGN AND MATERIALS

Pump Type: Heavy-duty, horizontal, peristaltic hose pump

Pump Configuration: Direct or close-coupled

Pump Housing Material: 413 Aluminum (polyester powder coated), NEMA 4X (IP66)

Cover Material: Polycarbonate

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Cover Seal Material: EPDM or Buna N (NBR)

Rotor Material: Valox (PBT)

Rotor Shoes: **[A: Aluminum] [B: Stainless Steel] [C:]**

No. of Rotor Shoes (Minimum): 2

Rotor Shoe Shim Material: Type 316 stainless steel

Hose Size, Millimeters: **[A: 10] [B: 15] [C: 25] [D: 32] [E: 40] [F: 50] [G: 65] [H: 80] [I: 100]**

Maximum Number of Hose Occlusions per 100 Gallons Pumped: **[A:]**

Hose Material: PVC, Polyethylene, Norprene

Hose Pressure Rating (psig): **[A: 230] [B: 125 psig]**

Hose Inserts Material: Polypropylene

Hose Lubricant: Manufacturer's standard

Flange Rating and Material: **[A: ANSI Class 125/150] [B: Carbon steel] [C: Type 316 stainless steel] [D:]**

Bearing Housing Material: Steel

Bearing Type: Ball bearings, permanently lubricated

Bearing Life (ABMA L-10) (hrs): **[A: 100,000] [B:]**

Gear Drive: **[A: Planetary type, AGMA Class II] [B:]**

Baseplate: Steel

High Level Leak Detector (Y/N): Y

Pump Speed Sensor (Y/N): _____

Revolution Sensor (Y/N): _____

Suction Pulsation Dampener (Y/N): N

Discharge Pulsation Dampener (Y/N): N

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DRIVE MOTOR (see Section 26 20 00, Low-Voltage AC Induction Motors)

Horsepower: 0.25 Voltage: 115 Phase: 3 Synchronous Speed (rpm): 125

Service Factor: 1.0 Inverter Duty (Y/N): _____

Enclosure: DIP _____ EXP _____ ODP _____ TEFC _____ CISD-TEFC _____
TENV _____ WPI _____ WPII _____ SUBM _____

[A: Adjustable Speed Drive Range: _____ min to _____ max, see Section 26 29 23, Low-Voltage Adjustable Frequency Drive Systems]

REMARKS_____

_____

_____

_____

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PERISTALTIC HOSE PUMP DATA SHEET 44 42 56.16-3

Tag Numbers: PMP-380-601-01, PMP-380-601-02

Pump Name: Sodium Hypochlorite Feed Pump 1, Sodium Hypochlorite Feed Pump 2

Manufacturer and Model Number: (1) Blue-White/ProSeries-M-3

SERVICE CONDITIONS

Liquid Pumped (Material and Percent): 10% Sodium Hypochlorite

Pumping Temperature (Fahrenheit): Normal: _____ Max 115F Min 14F

Specific Gravity @ 60 Degrees F: _____ Viscosity Range: _____

pH: _____

Abrasive (Y/N): N Possible Scale Buildup (Y/N): N

Inlet Pressure at Pump (psig): _____

Min. Net Positive Inlet Pressure Available (psia): _____

Area Classification: _____

PERFORMANCE REQUIREMENTS

Rated Capacity (gpm): 6.4 gph Rated Differential Pressure (psi): 100

Maximum Pump Speed at Rated Condition (rpm): 125

Constant Speed (Y/N): N Adjustable Speed (Y/N): Y

Speed Range: 0.001% to 100% of Rated Speed: _____

DESIGN AND MATERIALS

Pump Type: Heavy-duty, horizontal, peristaltic hose pump

Pump Configuration: Direct or close-coupled

Pump Housing Material: 413 Aluminum (polyester powder coated), NEMA 4X (IP66)

Cover Material: Polycarbonate

Cover Seal Material: EPDM or Buna N (NBR)

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Rotor Material: Valox (PBT)

Rotor Shoes: **[A: Aluminum] [B: Stainless Steel] [C:]**

No. of Rotor Shoes (Minimum): 2

Rotor Shoe Shim Material: Type 316 stainless steel

Hose Size, Millimeters: **[A: 10] [B: 15] [C: 25] [D: 32] [E: 40] [F: 50] [G: 65] [H: 80] [I: 100]**

Maximum Number of Hose Occlusions per 100 Gallons Pumped: **[A:]**

Hose Material: PVC, Polyethylene, Norprene

Hose Pressure Rating (psig): **[A: 230] [B: 125 psig]**

Hose Inserts Material: Polypropylene

Hose Lubricant: Manufacturer's standard

Flange Rating and Material: **[A: ANSI Class 125/150] [B: Carbon steel] [C: Type 316 stainless steel] [D:]**

Bearing Housing Material: Steel

Bearing Type: Ball bearings, permanently lubricated

Bearing Life (ABMA L-10) (hrs): **[A: 100,000] [B:]**

Gear Drive: **[A: Planetary type, AGMA Class II] [B:]**

Baseplate: Steel

High Level Leak Detector (Y/N): Y

Pump Speed Sensor (Y/N): _____

Revolution Sensor (Y/N): _____

Suction Pulsation Dampener (Y/N): N

Discharge Pulsation Dampener (Y/N): N

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DRIVE MOTOR (see Section 26 20 00, Low-Voltage AC Induction Motors)

Horsepower: 0.25 Voltage: 115 Phase: 3 Synchronous Speed (rpm): 125

Service Factor: 1.0 Inverter Duty (Y/N): _____

Enclosure: DIP _____ EXP _____ ODP _____ TEFC _____ CISD-TEFC _____
TENV _____ WPI _____ WPII _____ SUBM _____

[A: Adjustable Speed Drive Range: _____ min to _____ max, see Section 26 29 23, Low-Voltage Adjustable Frequency Drive Systems]

REMARKS_____

_____

_____

_____

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PERISTALTIC HOSE PUMP DATA SHEET 44 42 56.16-4

Tag Numbers: PMP-380-401-01, PMP-380-401-02, PMP-380-401-03

Pump Name: Sodium Hydroxide Feed Pump 1, Sodium Hydroxide Feed Pump 2, Sodium Hydroxide Feed Pump 3

Manufacturer and Model Number: (1) Blue-White/ProSeries-M-3

SERVICE CONDITIONS

Liquid Pumped (Material and Percent): 50% Sodium Hydroxide

Pumping Temperature (Fahrenheit): Normal: _____ Max 115F Min 14F

Specific Gravity @ 60 Degrees F: _____ Viscosity Range: _____

pH: _____

Abrasive (Y/N): N Possible Scale Buildup (Y/N): Y

Inlet Pressure at Pump (psig): _____

Min. Net Positive Inlet Pressure Available (psia): _____

Area Classification: _____

PERFORMANCE REQUIREMENTS

Rated Capacity (gpm): 15 gph Rated Differential Pressure (psi): 100

Maximum Pump Speed at Rated Condition (rpm): 125

Constant Speed (Y/N): N Adjustable Speed (Y/N): Y

Speed Range: 0.001% to 100% of Rated Speed: _____

DESIGN AND MATERIALS

Pump Type: Heavy-duty, horizontal, peristaltic hose pump

Pump Configuration: Direct or close-coupled

Pump Housing Material: 413 Aluminum (polyester powder coated), NEMA 4X (IP66)

Cover Material: Polycarbonate

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Cover Seal Material: EPDM or Buna N (NBR)

Rotor Material: Valox (PBT)

Rotor Shoes: **[A: Aluminum] [B: Stainless Steel] [C:]**

No. of Rotor Shoes (Minimum): 2

Rotor Shoe Shim Material: Type 316 stainless steel

Hose Size, Millimeters: **[A: 10] [B: 15] [C: 25] [D: 32] [E: 40] [F: 50] [G: 65] [H: 80] [I: 100]**

Maximum Number of Hose Occlusions per 100 Gallons Pumped: **[A:]**

Hose Material: PVC, Polyethylene, Norprene

Hose Pressure Rating (psig): **[A: 230] [B: 125 psig]**

Hose Inserts Material: Polypropylene

Hose Lubricant: Manufacturer's standard

Flange Rating and Material: **[A: ANSI Class 125/150] [B: Carbon steel] [C: Type 316 stainless steel] [D:]**

Bearing Housing Material: Steel

Bearing Type: Ball bearings, permanently lubricated

Bearing Life (ABMA L-10) (hrs): **[A: 100,000] [B:]**

Gear Drive: **[A: Planetary type, AGMA Class II] [B:]**

Baseplate: Steel

High Level Leak Detector (Y/N): Y

Pump Speed Sensor (Y/N): _____

Revolution Sensor (Y/N): _____

Suction Pulsation Dampener (Y/N): N

Discharge Pulsation Dampener (Y/N): N

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DRIVE MOTOR (see Section 26 20 00, Low-Voltage AC Induction Motors)

Horsepower: 0.25 Voltage: 115 Phase: 3 Synchronous Speed (rpm): 125

Service Factor: 1.0 Inverter Duty (Y/N): _____

Enclosure: DIP _____ EXP _____ ODP _____ TEFC _____ CISD-TEFC _____
TENV _____ WPI _____ WPII _____ SUBM _____

[A: Adjustable Speed Drive Range: _____ min to _____ max, see Section 26 29 23, Low-Voltage Adjustable Frequency Drive Systems]

REMARKS_____

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PERISTALTIC HOSE PUMP DATA SHEET 44 42 56.16-5

Tag Numbers: PMP-380-601-01, PMP-380-601-02, PMP-380-601-03

Pump Name: Anionic Polymer Feed Pump 1, Anionic Polymer Feed Pump 2, Anionic Polymer Feed Pump 3

Manufacturer and Model Number: (1) Blue-White/ProSeries-M-3

SERVICE CONDITIONS

Liquid Pumped (Material and Percent): Anionic Polymer

Pumping Temperature (Fahrenheit): Normal: _____ Max 115F Min 14F

Specific Gravity @ 60 Degrees F: _____ Viscosity Range: _____

pH: _____

Abrasive (Y/N): N Possible Scale Buildup (Y/N): N

Inlet Pressure at Pump (psig): _____

Min. Net Positive Inlet Pressure Available (psia): _____

Area Classification: _____

PERFORMANCE REQUIREMENTS

Rated Capacity (gpm): 36 gph Rated Differential Pressure (psi): 100

Maximum Pump Speed at Rated Condition (rpm): 125

Constant Speed (Y/N): N Adjustable Speed (Y/N): Y

Speed Range: 0.001% to 100% of Rated Speed: _____

DESIGN AND MATERIALS

Pump Type: Heavy-duty, horizontal, peristaltic hose pump

Pump Configuration: Direct or close-coupled

Pump Housing Material: 413 Aluminum (polyester powder coated), NEMA 4X (IP66)

Cover Material: Polycarbonate

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Cover Seal Material: EPDM or Buna N (NBR)

Rotor Material: Valox (PBT)

Rotor Shoes: **[A: Aluminum] [B: Stainless Steel] [C:]**

No. of Rotor Shoes (Minimum): 2

Rotor Shoe Shim Material: Type 316 stainless steel

Hose Size, Millimeters: **[A: 10] [B: 15] [C: 25] [D: 32] [E: 40] [F: 50] [G: 65] [H: 80] [I: 100]**

Maximum Number of Hose Occlusions per 100 Gallons Pumped: **[A:]**

Hose Material: PVC, Polyethylene, Norprene

Hose Pressure Rating (psig): **[A: 230] [B: 125 psig]**

Hose Inserts Material: Polypropylene

Hose Lubricant: Manufacturer's standard

Flange Rating and Material: **[A: ANSI Class 125/150] [B: Carbon steel] [C: Type 316 stainless steel] [D:]**

Bearing Housing Material: Steel

Bearing Type: Ball bearings, permanently lubricated

Bearing Life (ABMA L-10) (hrs): **[A: 100,000] [B:]**

Gear Drive: **[A: Planetary type, AGMA Class II] [B:]**

Baseplate: Steel

High Level Leak Detector (Y/N): Y

Pump Speed Sensor (Y/N): _____

Revolution Sensor (Y/N): _____

Suction Pulsation Dampener (Y/N): N

Discharge Pulsation Dampener (Y/N): N

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DRIVE MOTOR (see Section 26 20 00, Low-Voltage AC Induction Motors)

Horsepower: 0.25 Voltage: 115 Phase: 3 Synchronous Speed (rpm): 125

Service Factor: 1.0 Inverter Duty (Y/N): _____

Enclosure: DIP _____ EXP _____ ODP _____ TEFC _____ CISD-TEFC _____
TENV _____ WPI _____ WPII _____ SUBM _____

[A: Adjustable Speed Drive Range: _____ min to _____ max, see Section 26 29 23, Low-Voltage Adjustable Frequency Drive Systems]

REMARKS_____

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PERISTALTIC HOSE PUMP DATA SHEET 44 42 56.16-6

Tag Numbers: PMP-380-601-04, PMP-380-601-05

Pump Name: Anionic Polymer Feed Pump 4, Anionic Polymer Feed Pump 5

Manufacturer and Model Number: (1) Blue-White/ProSeries-M

SERVICE CONDITIONS

Liquid Pumped (Material and Percent): Anionic Polymer

Pumping Temperature (Fahrenheit): Normal: _____ Max 115F Min 14F

Specific Gravity @ 60 Degrees F:_____ Viscosity Range:_____

pH:_____

Abrasive (Y/N): N Possible Scale Buildup (Y/N): N

Inlet Pressure at Pump (psig): _____

Min. Net Positive Inlet Pressure Available (psia): _____

Area Classification: _____

PERFORMANCE REQUIREMENTS

Rated Capacity (gpm): 16.5 gph

Rated Differential Pressure (psi): 100

Maximum Pump Speed at Rated Condition (rpm): 125

Constant Speed (Y/N): N Adjustable Speed (Y/N): Y

Speed Range: 0.001% to 100% of Rated Speed: _____

DESIGN AND MATERIALS

Pump Type: Heavy-duty, horizontal, peristaltic hose pump

Pump Configuration: Direct or close-coupled

Pump Housing Material: 413 Aluminum (polyester powder coated), NEMA 4X (IP66)

Cover Material: Polycarbonate

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Cover Seal Material: EPDM or Buna N (NBR)

Rotor Material: Valox (PBT)

Rotor Shoes: **[A: Aluminum] [B: Stainless Steel] [C:]**

No. of Rotor Shoes (Minimum): 2

Rotor Shoe Shim Material: Type 316 stainless steel

Hose Size, Millimeters: **[A: 10] [B: 15] [C: 25] [D: 32] [E: 40] [F: 50] [G: 65] [H: 80] [I: 100]**

Maximum Number of Hose Occlusions per 100 Gallons Pumped: **[A:]**

Hose Material: PVC, Polyethylene, Norprene, or Tygothane

Hose Pressure Rating (psig): **[A: 230] [B: 125 psig]**

Hose Inserts Material: Polypropylene

Hose Lubricant: Manufacturer's standard

Flange Rating and Material: **[A: ANSI Class 125/150] [B: Carbon steel] [C: Type 316 stainless steel] [D:]**

Bearing Housing Material: Steel

Bearing Type: Ball bearings, permanently lubricated

Bearing Life (ABMA L-10) (hrs): **[A: 100,000] [B:]**

Gear Drive: **[A: Planetary type, AGMA Class II] [B:]**

Baseplate: Steel

High Level Leak Detector (Y/N): Y

Pump Speed Sensor (Y/N): _____

Revolution Sensor (Y/N): _____

Suction Pulsation Dampener (Y/N): N

Discharge Pulsation Dampener (Y/N): N

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DRIVE MOTOR (see Section 26 20 00, Low-Voltage AC Induction Motors)

Horsepower: 0.25 Voltage: 115 Phase: 3 Synchronous Speed (rpm): 125

Service Factor: 1.0 Inverter Duty (Y/N): _____

Enclosure: DIP _____ EXP _____ ODP _____ TEFC _____ CISD-TEFC _____
TENV _____ WPI _____ WPII _____ SUBM _____

[A: Adjustable Speed Drive Range: _____ min to _____ max, see Section 26 29 23, Low-Voltage Adjustable Frequency Drive Systems]

REMARKS_____

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PERISTALTIC HOSE PUMP DATA SHEET 44 42 56.16-7

Tag Numbers: PMP-380-501-01, PMP-380-501-02

Pump Name: Nonionic or Cationic Polymer Feed Pump 1, Nonionic or Cationic Polymer Feed Pump 2

Manufacturer and Model Number: (1) Blue-White/ProSeries-M-3

SERVICE CONDITIONS

Liquid Pumped (Material and Percent): Cationic or Nonionic Polymer

Pumping Temperature (Fahrenheit): Normal: _____ Max 115F Min 14F

Specific Gravity @ 60 Degrees F: _____ Viscosity Range: _____

pH: _____

Abrasive (Y/N): N Possible Scale Buildup (Y/N): N

Inlet Pressure at Pump (psig): _____

Min. Net Positive Inlet Pressure Available (psia): _____

Area Classification: _____

PERFORMANCE REQUIREMENTS

Rated Capacity (gpm): 7 gph Rated Differential Pressure (psi): 100

Maximum Pump Speed at Rated Condition (rpm): 125

Constant Speed (Y/N): N Adjustable Speed (Y/N): Y

Speed Range: 0.001% to 100% of Rated Speed: _____

DESIGN AND MATERIALS

Pump Type: Heavy-duty, horizontal, peristaltic hose pump

Pump Configuration: Direct or close-coupled

Pump Housing Material: 413 Aluminum (polyester powder coated), NEMA 4X (IP66)

Cover Material: Polycarbonate

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Cover Seal Material: EPDM or Buna N (NBR)

Rotor Material: Valox (PBT)

Rotor Shoes: **[A: Aluminum] [B: Stainless Steel] [C:]**

No. of Rotor Shoes (Minimum): 2

Rotor Shoe Shim Material: Type 316 stainless steel

Hose Size, Millimeters: **[A: 10] [B: 15] [C: 25] [D: 32] [E: 40] [F: 50] [G: 65] [H: 80] [I: 100]**

Maximum Number of Hose Occlusions per 100 Gallons Pumped: **[A:]**

Hose Material: PVC, Polyethylene, Norprene or Tygothane tubing

Hose Pressure Rating (psig): **[A: 230] [B: 125 psig]**

Hose Inserts Material: Polypropylene

Hose Lubricant: Manufacturer's standard

Flange Rating and Material: **[A: ANSI Class 125/150] [B: Carbon steel] [C: Type 316 stainless steel] [D:]**

Bearing Housing Material: Steel

Bearing Type: Ball bearings, permanently lubricated

Bearing Life (ABMA L-10) (hrs): **[A: 100,000] [B:]**

Gear Drive: **[A: Planetary type, AGMA Class II] [B:]**

Baseplate: Steel

High Level Leak Detector (Y/N): Y

Pump Speed Sensor (Y/N): _____

Revolution Sensor (Y/N): _____

Suction Pulsation Dampener (Y/N): N

Discharge Pulsation Dampener (Y/N): N

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DRIVE MOTOR (see Section 26 20 00, Low-Voltage AC Induction Motors)

Horsepower: 0.25 Voltage: 115 Phase: 3 Synchronous Speed (rpm): 125

Service Factor: 1.0 Inverter Duty (Y/N): _____

Enclosure: DIP _____ EXP _____ ODP _____ TEFC _____ CISD-TEFC _____
TENV _____ WPI _____ WPII _____ SUBM _____

[A: Adjustable Speed Drive Range: _____ min to _____ max, see Section 26 29 23, Low-Voltage Adjustable Frequency Drive Systems]

REMARKS_____

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PERISTALTIC HOSE PUMP DATA SHEET 44 42 56.16-8

Tag Numbers: PMP-380-701-01, PMP-380-701-02

Pump Name: Phosphoric Acid/Ortho Polyphosphate Feed Pump 1, Phosphoric Acid/Ortho Polyphosphate Feed Pump 2

Manufacturer and Model Number: (1) Blue-White/ProSeries-M-3

SERVICE CONDITIONS

Liquid Pumped (Material and Percent): Cationic or Nonionic Polymer

Pumping Temperature (Fahrenheit): Normal: _____ Max 115F Min 14F

Specific Gravity @ 60 Degrees F: _____ Viscosity Range: _____

pH: _____

Abrasive (Y/N): N Possible Scale Buildup (Y/N): N

Inlet Pressure at Pump (psig): _____

Min. Net Positive Inlet Pressure Available (psia): _____

Area Classification: _____

PERFORMANCE REQUIREMENTS

Rated Capacity (gpm): 1.25 gph Rated Differential Pressure (psi): 100

Maximum Pump Speed at Rated Condition (rpm): 125

Constant Speed (Y/N): N Adjustable Speed (Y/N): Y

Speed Range: 0.001% to 100% of Rated Speed: _____

DESIGN AND MATERIALS

Pump Type: Heavy-duty, horizontal, peristaltic hose pump

Pump Configuration: Direct or close-coupled

Pump Housing Material: 413 Aluminum (polyester powder coated), NEMA 4X (IP66)

Cover Material: Polycarbonate

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Cover Seal Material: EPDM or Buna N (NBR)

Rotor Material: Valox (PBT)

Rotor Shoes: **[A: Aluminum] [B: Stainless Steel] [C:]**

No. of Rotor Shoes (Minimum): 2

Rotor Shoe Shim Material: Type 316 stainless steel

Hose Size, Millimeters: **[A: 10] [B: 15] [C: 25] [D: 32] [E: 40] [F: 50] [G: 65] [H: 80] [I: 100]**

Maximum Number of Hose Occlusions per 100 Gallons Pumped: **[A:]**

Hose Material: PVC, Polyethylene, Norprene or Tygothane tubing

Hose Pressure Rating (psig): **[A: 230] [B: 125 psig]**

Hose Inserts Material: Polypropylene

Hose Lubricant: Manufacturer's standard

Flange Rating and Material: **[A: ANSI Class 125/150] [B: Carbon steel] [C: Type 316 stainless steel] [D:]**

Bearing Housing Material: Steel

Bearing Type: Ball bearings, permanently lubricated

Bearing Life (ABMA L-10) (hrs): **[A: 100,000] [B:]**

Gear Drive: **[A: Planetary type, AGMA Class II] [B:]**

Baseplate: Steel

High Level Leak Detector (Y/N): Y

Pump Speed Sensor (Y/N): _____

Revolution Sensor (Y/N): _____

Suction Pulsation Dampener (Y/N): N

Discharge Pulsation Dampener (Y/N): N

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DRIVE MOTOR (see Section 26 20 00, Low-Voltage AC Induction Motors)

Horsepower: 0.25 Voltage: 115 Phase: 3 Synchronous Speed (rpm): 125

Service Factor: 1.0 Inverter Duty (Y/N): _____

Enclosure: DIP _____ EXP _____ ODP _____ TEFC _____ CISD-TEFC _____
TENV _____ WPI _____ WPII _____ SUBM _____

[A: Adjustable Speed Drive Range: _____ min to _____ max, see Section 26 29 23, Low-Voltage Adjustable Frequency Drive Systems]

REMARKS_____

_____

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SECTION 44 42 56.17
SAMPLING PUMPS

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Bearing Manufacturers' Association (ABMA).
2. Hydraulic Institute Standards (HIS).
3. National Electrical Manufacturer's Association (NEMA): MG 1, Motors and Generators.
4. Underwriters Laboratory (UL).

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Make, model, weight, and horsepower of each equipment assembly.
   b. Complete catalog information, descriptive literature, specifications, and identification of materials of construction.
   c. Performance data curves showing head, capacity, horsepower demand, and pump efficiency over the entire operating range of the pump, from shutoff to maximum capacity. **[A: Indicate separately the head, capacity, horsepower demand, overall efficiency, and minimum submergence required at the guarantee point.]**
   d. Detailed **[B: structural,] [C: mechanical,] [D: and] [E: electrical]** drawings showing the equipment dimensions, size, and locations of connections and weights of associated equipment.
   e. Power and control wiring diagrams, including terminals and numbers.
   f. Complete motor nameplate data, as defined by NEMA, motor manufacturer, and including any motor modifications.
   g. Factory finish system.
   h. Seismic anchorage and bracing drawings and cut sheets, as required by Section 01 88 15, Anchorage and Bracing.

B. Informational Submittals:

1. Seismic anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.

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2. **[A: Manufacturer's Certificate of Compliance, in accordance with Section [B: 01 61 00, Common Product Requirements] [C:], that factory finish system is identical to requirements specified herein.]**
3. **[D: Factory Functional] [E: and] [F: Performance] [G: Test Report] [H: and Log]**.
4. Special shipping, storage and protection, and handling instructions.
5. Manufacturer's printed installation instructions.
6. Suggested spare parts list to maintain the equipment in service for a period of **[I: 1 year] [J: and] [K: 5 years]**. Include a list of special tools required for checking, testing, parts replacement, and maintenance with current price information.
7. List special tools, materials, and supplies furnished with equipment for use prior to and during startup and for future maintenance.
8. Operation and Maintenance Data: As specified in Section 01 78 23, Operation and Maintenance Data.
9. Manufacturer's Certificate of Proper Installation, in accordance with Section **[L: 01 43 33, Manufacturers' Field Services] [M:]**.

1.03 EXTRA MATERIALS

A. Furnish for **[A: each pump] [B: this set of pumps]**:

1. **[C: Complete set packing.]**
2. **[D: Complete set of bearings.]**
3. **[E: Complete set gaskets and O-ring seals.]**
4. **[F: Complete set rod washers.]**
5. **[G: Complete set keys, dowels, pins.]**
6. **[H:___stators.]**
7. **[I:__ rotors.]**
8. **[J:__ connecting rods with [K:] or [L:] pair of universal joint(s), as required by pump type.]**
9. **[M: One complete set of any special tools required to dismantle pump.]**

PART 2 PRODUCTS

2.01 GENERAL

A. Coordinate pump requirements with drive manufacturer and be responsible for pump and drive requirements.

B. Where adjustable speed drives are required, furnish a coordinated operating system complete with pump, drive, and speed controller.

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2.02 SUPPLEMENTS

A. Some specific requirements are attached to this section as supplements.

B. **[A: No "or-equal" or substitute products will be considered.]**

2.03 ACCESSORIES

A. Equipment Identification Plate: 16-gauge stainless steel with 1/4-inch die-stamped equipment tag number securely mounted in a readily visible location.

B. Lifting Lugs: Equipment weighing over 100 pounds.

C. Anchor Bolts: **[A: Galvanized,] [B: Type 316 stainless steel,] [C: sized by equipment manufacturer,] [D: 1/2-inch minimum diameter,]** and as specified in Section 05 50 00, Metal Fabrications. **[E: Coat in accordance with Section 09 90 00, Painting and Coating.]**

2.04 FACTORY FINISHING

A. **[A: Prepare, [B: and] prime, [C: and finish] coat in accordance with Section 09 90 00, Painting and Coating]**.

B. **[A: Manufacturer's standard [B: baked] enamel finish.]**

2.05 SOURCE QUALITY CONTROL

A. **[A: Factory Inspections:]** Inspect **[B: control panels] [C:]** for required construction, electrical connection, and intended function.

B. **[A: Factory Tests and Adjustments:]** Test **[B: one] [C:] [D: all] [E: equipment] [F:] [G: and] [H: control panels [I: actually] [J: identical to that]]** furnished.

C. Factory Test Report: Include **[A: test data sheets,] [B: curve test results,] [C: certified correct by a registered professional engineer]**.

D. Functional Test: Perform **[A: manufacturer's standard,] [B:] [C: motor]** test on **[D: equipment] [E:]**.

E. Performance Test:

1. Conduct on each pump.
2. Conduct in accordance with Hydraulic Institute Standards.
3. Perform under simulated operating conditions.
4. Test for a continuous **[A: 3-hour] [B:]** period without malfunction.

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5. Test Log: Record the following:
    a. **[C: Total head.]**
    b. **[D: Capacity.]**
    c. **[E: Horsepower requirements.]**
    d. **[F: Flow measured by factory instrumentation and storage volumes.]**
    e. **[G: Average distance from suction well water surface to pump discharge centerline for duration of test.]**
    f. **[H: Pump discharge pressure converted to feet of liquid pumped and corrected to pump discharge centerline.]**
    g. **[I: Calculated velocity head at the discharge flange.]**
    h. **[J: Field head.]**
    i. **[K: Driving motor voltage and amperage measured for each phase.]**
6. Adjust, realign, or modify units and retest **[L: in accordance with [M: Hydraulic Institute Standards] [N:]]** if necessary.

F. Motor Test: See Section **[A: 26 20 00, Low-Voltage AC Induction Motors]** [**B: 26 19 00, Medium-Voltage AC Induction Motors]**.

G. **[A: Hydrostatic Tests: Pump casing(s) tested at 150 percent of shutoff head. Test pressure maintained for not less than 5 minutes.]**

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer's printed instructions.

B. Level base by means of steel wedges (steel plates and steel shims). Wedge taper not greater than 1/4 inch per foot. Use double wedges to provide a level bearing surface for pump and driver base. Accomplish wedging so there is no change of level or springing of baseplate when anchor bolts are tightened.

C. Adjust pump assemblies such that the driving units are properly aligned, plumb, and level with the driven units and all interconnecting shafts and couplings. Do not compensate for misalignment by use of flexible couplings.

D. After pump and driver have been set in position, aligned, and shimmed to proper elevation, grout space between bottom of baseplate and concrete foundation with poured, nonshrinking grout of proper category, as specified in Section 03 62 00, Nonshrink Grouting. Remove wedges after grout is set and pack void with grout.

E. Connect suction and discharge piping without imposing strain to pump flanges.

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F. Anchor Bolts: Accurately place using equipment templates and as specified in Section 05 50 00, Metal Fabrications.

G. Pipe pump drain(s) to **[A: hub drain] [B: or scupper]**.

3.02 FIELD FINISHING

A. Equipment as specified in Section 09 90 00, Painting and Coating.

3.03 FIELD QUALITY CONTROL

A. Conduct tests on each pump.

B. Functional Tests:

1. Alignment: Test complete assemblies for **[A: correct rotation,]** proper alignment and connection, and quiet operation.
2. Vibration Test:
   a. Test with unit installed and in normal operation, and discharging to the connected piping systems at rates **[B: between low discharge head and high discharge head conditions specified,] [C:] [D: and with actual building structures and foundations provided]** shall not develop vibration exceeding the **[E: 80 percent] [F:]** of the limits specified in HIS 9.6.4.
   b. If units exhibit vibration in excess of the limits **[G: specified] [H: adjust] [I: or modify]** as necessary. **[J: Units that cannot be adjusted or modified to conform as specified shall be replaced.]**

C. Performance Test: In accordance with Hydraulic Institute Standards.

3.04 MANUFACTURER'S SERVICES

A. Manufacturer's Representative: Present at Site or classroom designated by **[A: Owner,] [B: ,]** for minimum person-days listed below, travel time excluded:

1. **[C:]** person-days for **[D: installation assistance] [E: and] [F: inspection.]**
2. **[G:]** person-days for **[H: functional] [I: and] [J: performance]** testing and completion of Manufacturer's Certificate of Proper Installation.
3. **[K:]** person-days for prestartup classroom or Site training.
4. **[L:]** person-days for facility startup.

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5. **[M:]** person-days for post-startup training **[N: of Owner's personnel.] [O: Training shall not commence until an accepted detailed lesson plan for each training activity has been reviewed by] [P: Owner] [Q: Engineer] [R:]**.

B. See **[A: Section 01 43 33, Manufacturers' Field Services] [B: and] [C: Section 01 91 14, Equipment Testing and Facility Startup.]**

3.05 SUPPLEMENTS

A. The supplements listed below, following "End of Section," are a part of this Specification.

1. Pump Data Sheet.

END OF SECTION

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SAMPLING PUMP DATA SHEET 44 42 56.17-__

Tag Numbers:_____

Pump Name:_____

Manufacturer and Model Number: (1) _____
(2) _____
(3) _____

SERVICE CONDITIONS

Liquid Pumped (Material and Percent): _____

Pumping Temperature (Fahrenheit): Normal: _____ Max _____ Min _____

Specific Gravity @ 60 Degrees F: _____ Viscosity Range: _____

pH: _____

Abrasive (Y/N): _____ Possible Scale Buildup (Y/N): _____

Inlet Pressure at Pump (psig): _____

Min. Net Positive Inlet Pressure Available (psia): _____

PERFORMANCE REQUIREMENTS

Rated Capacity: _____ US gpm at _____ psi differential pressure.

Range (US gpm) _____

Max. Pump Speed (rpm): _____ Constant (Y/N): _____ Adjustable (Y/N): _____

Speed Range: ____% to____% of Rated Speed: _____ Constant Torque (Y/N):____

DESIGN AND MATERIALS

Pump Body Material: _____ Drive Housing Material: _____

Pump Stages: _____

Connections:
Suction: Flanged: ____ Flange Type: ____ Open-Throat: _____ Screwed: ____
Discharge: Flanged: _____ Flange Type: _____ Screwed: _____

Suction Port: _____

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Stator Material: _____ Stator Thermal Protection (Y/N): _____

Rotor Material: _____

Connecting Rod Material: _____ Drive Shaft Material: _____

Joints: Gear Type Universal (Y/N): ___ Pin Type Universal (Y/N): ___ Other: ____

Shaft Sleeve (Y/N): _____ Material: _____

Shaft Seal: Packing (Y/N): _____ Material: _____
Lantern Ring (Y/N): _____ Material: _____
Mechanical (Y/N): _____ Type: _____
Lubrication: _____

ABMA B-10 Bearing Life (hrs): _____ Lubrication: _____

Coupling: Falk (Y/N): _____ Fast (Y/N): _____
Gear Type (Y/N): _____ Manufacturer Standard (Y/N): _____

Baseplate: Design: _____ Material: _____

Drive Type: Direct-Coupled: _____ Belt: ____ Hydrostatic Adjustable Speed: _____
Close Coupled Gear Reducer: _____ Other: _____

DRIVE MOTOR (See Section **[A: 26 20 00, Low-Voltage AC Induction Motors]** [**B: 26 19 00, Medium-Voltage AC Induction Motors]**.)

Horsepower: _____ Voltage: _____ Phase: _____ Base Speed (rpm): _____

Service Factor: _____Inverter Duty (Y/N) _____

Motor nameplate horsepower shall not be exceeded at any head-capacity point on the pump curve.

Enclosure: DIP _____ EXP _____ ODP _____ TEFC _____ CISD-TEFC _____
TENV _____ WPI _____ WPII _____ SUBM _____

Drive Arrangement: In-Line: _____ Vertical "Z": _____ Piggy Back: _____
Horizontal Offset: _____ C-Face Mounted: _____

Nonreverse Ratchet (Y/N): _____

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REMARKS _____

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SECTION 44 43 30
FILTER MEDIA

PART 1 GENERAL

1.01 ALTERNATES

A. Refer to Section 01 11 00, Summary of Work for description of Work under this section affected by alternates.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Water Works Association (AWWA): B100, Filtering Material.
2. NSF International (NSF):
   a. NSF/ANSI 61, Drinking Water System Components - Health Effects.
   b. NSF/ANSI 372, Drinking Water System Components - Lead Content.

1.03 SUBMITTALS

A. Action Submittals:

1. Shop Drawings: Submit not less than 30 days prior to shipment manufacturer's product information, including grain size ranges for each gravel and fine media layer specified. Gravel sizes shall be in inches or U.S. sieve sizes. Fine media sizes shall be in millimeters.
2. Samples: Submit Sample of gravel and fine media material following delivery of shipment.

B. Informational Submittals: Submit gradation test results of fine media, including sieve analysis prior to loading and shipment.

PART 2 PRODUCTS

2.01 GENERAL

A. Components and Materials in Contact with Water for Human Consumption: Comply with the requirements of the Safe Drinking Water Act and other applicable federal, state, and local requirements. Provide certification by manufacturer or an accredited certification organization recognized by the Authority Having Jurisdiction that components and materials comply with the

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maximum lead content standard in accordance with NSF/ANSI 61 and NSF/ANSI 372.

1. Use or reuse of components and materials without a traceable certification is prohibited.

2.02 MANUFACTURERS

A. Fine Media (Silica Sand):

1. Unifilt Corp.
2. F.B. Leopold Co.
3. Turbotrol Co.
4. Northwest Filter Co.
5. MicroFLOC Products.

B. Granular Activated Carbon (GAC):

1. Calgon Caron Corporation.
2. Norit Americas, Inc.
3. The manufacturer shall have a minimum 10 years' experience in supplying GAC to water treatment plants.

2.03 GRANULAR ACTIVATED CARBON FILTERS

A. Granular Activated Carbon:

1. The GAC shall be clean, hard, durable particles in conformance with AWWA B604-05, modified as follows:
   a. Deliver GAC in bulk containers (supersacks are acceptable) or bulk trailer.
   b. The GAC shall be ANSI/NSF 61 certified virgin material manufactured from select grades of North American bituminous coal having the following properties:
      1) Particle Size Distribution: Carbon with maximum of 5 percent by weight larger than No. 8 mesh (2.36 mm) sieve and maximum of 4 percent by weight smaller than No. 20 mesh (0.85 mm) sieve.
      2) GAC with effective size of 1.0 mm to 1.15 mm, uniformity coefficient of no greater than 1.40.
      3) Minimum abrasion number of 80 (80 percent as determined by either the stirring abrasion test or the Ro-Tap abrasion test).
      4) Minimum hardness number 90 percent by weight.
      5) Minimum adsorptive capacity as measured by iodine number of 900 mg/iodine/g carbon.

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6) Minimum surface area of 900 sq m/g.
7) Maximum water soluble ash of 0.5 percent by weight.
8) Maximum total ash content of 9 percent by weight.
9) Maximum moisture as packed of 2 percent by weight.
10) Real density of 2.1 g/cm^3.
11) Apparent density, backwashed and drained of 0.46 g/cm^3 to 0.65 g/cm^3.
12) Particle density, wetted in water of 1.3 g/cm^3 to 1.4 g/cm^3.
13) Pore volume of 0.75 g/cm^3 to 0.85 cm^3/g.

B. Silica Sand:

1. Clean, hard, durable particles in conformance with AWWA B100, modified as follows:
   a. Silica sand of specific gravity not less than 2.6, effective size 0.45 millimeter to 0.55 millimeter, and uniformity coefficient not more than 1.40.

2.04 SOURCE QUALITY CONTROL

A. Sampling:

1. Sampling in accordance with procedures specified in AWWA B100.
2. The media supplier shall perform sieve analyses and determination of specific gravity on the media prior to shipment.

B. Testing:

1. The preshipment media testing shall be performed by an independent test laboratory retained by the filter media supplier.
2. Sieve analyses shall be performed in accordance with AWWA B100. Test reports shall include raw data, graphical results, computation of effective size, and uniformity coefficient.
3. The specific gravity shall be determined for each sample. Testing shall be in accordance with AWWA B100, AWWA B604, and ASTM C128.

PART 3 EXECUTION

3.01 INSTALLATION

A. General:

1. CH2M not media manufacturer/supplier will be responsible for media installation.
2. Do not permit workers to walk or stand directly on media that are less than 1/2 inch in diameter. Use boards that will sustain workers' weight without displacing media.

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3. Before media is placed, mark top of all layers on side of filter.
4. GAC depletes oxygen from air and can be hazardous in a confined situation. CH2M shall be responsible for worker's safety and follow all local, state and federal guidelines pertaining to confined areas.
5. The replacement of GAC shall be installed so as to minimize abrasion and dust. If installed dry, basin shall be partially filled with water to cushion the media as it is unloaded. For dry media installation, schedule activities to allow 24 hours for media to properly wet prior to continuing work.

B. Fine Media:

1. Transport and place fine media carefully to prevent contamination of any sort.
2. Replace contaminated media (filter media that contains more than 0.5 percent of foreign material by weight) which becomes contaminated either before or after it has been placed in the filters with clean media.
3. Level fine media by hand to within plus or minus 6 inches of the appropriate mark prior to backwashing.
4. Install filter media in the following sequence:
    a. Place 12 inches plus adequate allowance for scrapings of silica sand and level.
    b. Backwash bed a minimum of three times and remove surface fines by scraping after each washing.
    c. Ensure required depth is met prior to placing next media layer.
    d. Place 24 inches of granular activated carbon plus adequate allowance for scrapings of granular activated carbon and finish off smooth to proper elevation.
    e. Backwash bed three times, and remove minimum of 1/2 inch of surface fines by scraping after each washing.
    f. Filter media installation requires approval of CH2M HILL's Engineer. CH2M HILL's Engineer will inspect filter media to ensure that fines are adequately removed through skimming. Notify CH2M HILL's Engineer and provide safe access to installed filter media for inspection after backwashing but before skimming each lift. Notify CH2M HILL's Engineer and provide safe access to installed filter media for inspection prior to installation of subsequent lifts and for final inspection after all skimming is complete.
    g. Place a second lift of 24 inches of GAC media plus adequate allowance for scrapings and finish off smooth to proper elevation following procedures outlined above.
5. Final depth of fine media after washing and scraping shall be 54 inches plus 1 inch to minus 1/2 inch.

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3.02 FIELD QUALITY CONTROL

A. Sampling:

1. 0.45 Millimeter to 0.55 Millimeter Effective Size Sand:
   a. Sampling shall be in accordance with AWWA B100.
   b. After media is delivered and placed, CH2M shall employ an independent testing agency to collect representative samples for testing.
   c. Sample each individual filter and label results accordingly.
   d. Each sample shall consist of sufficient media as required per AWWA B100 and ASTM C136.
2. 1.0 Millimeter to 1.10 Millimeter Effective Size GAC:
   a. Sample each individual filter and label results accordingly.
   b. Remove and discard sand from core samples.
   c. Core samples from each cell shall be combined per the recommendations of AWWA B100, including a minimum of five individual full-depth-of-GAC samples distributed over the filter area, to create a single composite core sample for each filter.

B. Testing:

1. The post-shipment media testing shall be performed by Bowser-Morner, Inc.
2. For all gradation testing, determination of effective size and uniformity coefficient shall utilize the current version of “ASTM Particle Sizing Analysis” software by Professional Analytical and Consulting Services, Pittsburgh, PA. No “Or-equal” or substitutions will be allowed.
3. The specific gravity shall be determined for each sample. Testing shall be in accordance with AWWA B100 and ASTM C128.
4. Sieve analyses and gradation testing shall be performed in accordance with AWWA B100 for each sample. Test reports shall include complete report generated by the particle sizing software. All raw sieve analysis data and the calculated effective size and uniformity coefficient shall be included in or appended to the report.

3.03 DISINFECTION

A. After installation of media is completed, disinfect media in accordance with the requirements of Section 33 13 00, Disinfecting of Water Utility Distribution.

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3.04 MANUFACTURER'S SERVICES

A. Provide a manufacturer's Certificate of Proper Installation in accordance with the Contract for both sand and granular activated carbon media.

END OF SECTION

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SECTION 44 43 34
FILTER UNDERDRAIN SYSTEM

PART 1 GENERAL

1.01 WORK INCLUDED

A. This section includes providing the dual lateral filter underdrain system and all appurtenant work in the following applications: Five gravity filter boxes each composed of one filter bay with approximate dimensions of 10 feet by 14 feet 10 inches.

B. Unit Responsibility: The Work requires that the filter underdrain system complete with all accessories and appurtenances be the end product of one responsible system manufacturer or responsible system supplier. Unless otherwise indicated, CH2M shall obtain each system from the responsible supplier of the equipment. The Supplier shall furnish and/or coordinate all components and accessories as necessary to place the equipment in operation in conformance with the specified performance, features, and functions indicated without altering or modifying CH2M's responsibilities under the Contract Documents. The Subcontractor is responsible to CH2M for providing the equipment systems as specified herein.

C. General Requirements: See Division 1, General Requirements, which contains information and requirements that apply to the work specified herein and are mandatory for this Project.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Society of Mechanical Engineers (ASME):
   a. B16.1, Gray Iron Pipe Flanges and Flanged Fittings (Classes 25, 125, and 250).
   b. B16.5, Pipe Flanges and Flange Fittings NPS 1/2 Through NPS 25 Metric/Inch Standard.
2. ASTM International (ASTM):
   a. A380, Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems.
   b. C881/C881M, Standard Specification for Epoxy-Resin-Base Bonding System for Concrete.
   c. C882/C882M, Standard Test Method for Bond Strength of Epoxy-Resin Systems Used with Concrete by Slant Shear.
   d. D648, Standard Test Method for Deflection Temperature of Plastics Under Flexural Load in the Edgewise Position.

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e. D695, Standard Test Method for Compressive Properties of Rigid Plastics.

3. NSF, International: 61, Drinking Water System Components—Health Effects.

1.03 SYSTEM DESCRIPTION

A. Design Requirements:

1. Design filter underdrain system, including, but not limited to, the underdrain laterals and drop legs, air scour header, and support cap system shall be designed by the filter underdrain system manufacturer.
2. Compatible with filter media being supplied; refer to Section 44 43 30, Filter Media.
3. Flow:
   a. Produce uniform air and water flows throughout filter box.
   b. Flow uniformity per square foot of filter underdrain area shall be as required to permit efficient and effective operation during filtration and backwashing.
   c. There shall be no localized areas with flow rates which would cause mounding, lateral displacement, or other deleterious disturbances in filter media.
   d. Size air scour header and risers to produce uniform air flows throughout filter bay. In addition:
      1) The air scour header shall not be larger than 8 inches diameter (nominal size). This limit is intended to allow the header to connect to main air header.
      2) For damage resistance and for mechanical strength, the risers shall not be smaller than 1-inch diameter (nominal). The risers shall be sized by the filter manufacturer to allow for proper air distribution.
4. System shall ensure operating characteristics have long-term stability and resistant to the following:
   a. Corrosion.
   b. Changes in head loss.
   c. Changes in flow uniformity.
   d. Other effects which would over time cause loss of efficiency or effectiveness of operation.
5. System Design Loads:
   a. Withstand net downward loading of not less than 1,400 psf, plus system's own dead weight.
   b. When installed, withstand net internal loading (burst pressure) of greater than or equal to twice the maximum head loss experienced at maximum backwash rates and not less than 5 psig. No credit shall be taken for weight of filter media.

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c. Withstand specified loadings, including anchorages and supports.
d. Address loads incurred during shipment, delivery, storage, handling, installation, and operation.

6. Support and Restraint:
   a. Underdrain and air scour header and drop legs shall be anchored as required to resist buoyant forces and dynamic forces during operation.
   b. Underdrain laterals shall not require support or restraint to resist specified burst pressure.
   c. Safety Factor: 2.0, minimum, to account for transient pressures which may occur during initiation and termination of air and water flows during backwash.
   d. Filter air scour header assemblies shall be designed to be supported inside flume.

B. System Performance Requirements:

1. As installed, shall satisfy the following criteria for minimum acceptable flow uniformity. Maldistribution of air and water flows during backwash, for all indicated flow conditions, shall not exceed:
   a. Water: Plus or minus 5 percent of average gpm per square foot of filter underdrain area.
   b. Air: Plus or minus 10 percent of average scfm per square foot of filter underdrain area
2. Evenly distribute air, water, and combined air/water flows and perform satisfactorily when operated under the following conditions:
   a. Filtration (Downflow) Mode: Water (filtrate) at rates up to 10 gpm per square foot of filter underdrain area.
   b. Backwash (Upflow) Mode:
      1) Air Rate:
         a) 2 scfm per square foot of filter underdrain area for air wash only.
         b) 2 scfm per square foot concurrent with water at rates of between 2 gpm and 5.3 gpm per square foot while overflowing backwash troughs.
      2) Water Rates: Up to 18 gpm per square foot of filter underdrain area.
3. Total water flow head loss across underdrain system, including caps, covers, or screens, shall not exceed the following:
   a. 48 inches water column (WC) of head loss when supplied with water flow of up to 18 gpm per square foot at 75 degrees F in backwash mode.
   b. 12 inches WC of head loss when supplied with water flow of up to 6 gpm per square foot at 75 degrees F in filtration mode.

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4. Water flow head losses across underdrain system shall include losses associated with underdrain and equalizing or secondary flume inside filter bay.
    a. Head losses shall include losses between lower gullet wall opening to just above integral support cap on top of underdrain.
    b. Head losses exclude static head of water above integral support cap as well as losses through media.
5. Air flow head loss across filter air scour header and drop legs, and underdrain laterals shall not exceed the following:
    a. 12 inches WC of head loss when supplied with concurrent air and water flows of up to 2.0 scfm per square foot of air flow and up to 5.3 gpm per square foot of water flow at 75 degrees F in backwash mode.
    b. These air flow head losses across the filter air scour header, drop legs, and underdrain laterals shall include all losses associated with the air scour header assemblies and underdrain lateral. Hence the head losses shall include all losses from the upstream flange on the air scour header within the filter basin to just downstream of (above) the distributions orifices in the top of the underdrain. These head losses exclude the static head of water above the underdrain.
6. Media-retaining, integral support cap system shall:
    a. Be compatible with filter underdrain system and with filter media.
    b. Retain filter media.
    c. Be appropriate for combined air/water backwash.
    d. Be compatible with filter media operating as an engineered biological filter for drinking water applications.

1.04 SUBMITTALS

A. Action Submittals:

1. Manufacturer’s catalog cuts and technical literature describing proposed filter underdrain system.
2. Shop Drawings: Scaled and dimensioned drawings showing layout and configuration.
3. Written interface requirements, installation details, and recommendations as are necessary to properly interface filter underdrain system with surrounding structures. The package shall provide sufficient guidance to Subcontractor so that the filter structure can be appropriately modified to accommodate the underdrain system. These interface requirements shall be approved by CH2M’s Engineer before the filter underdrain system manufacturer provides them to CH2M for construction.

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4. Complete and explicit details of design, construction, and operating characteristics of proposed filter underdrain system and complete test reports and design calculations showing conformity with all pneumatic and hydraulic (air and water flow) and all structural design requirements. Submittal data shall address the full range of flow conditions. Indicate pertinent physical relationships (location, relative size) among various air and water orifices, including those in lower gullet walls.
5. Submit anchorage and bracing drawings and cut sheets as required in Section 01 88 15, Anchorage and Bracing.
6. Include the following:
    a. Materials of construction.
    b. Head loss data for air, water, and combined air/water flows.
    c. Maximum percentage of flow maldistribution within filter for air, water, and combined air/water flows.
    d. Cross-sectional areas for flow of air and water and resulting velocities at pertinent points (e.g., gullet, lateral, orifices) throughout underdrain system (i.e., from inside lower gullet to just above media support cap).
    e. Relative magnitudes of entrance, transport, metering, and discharge losses.
    f. Other data necessary to demonstrate conformance with requirements of Contract Documents.
7. Delivery, storage, handling, installation, field testing, operating, and maintenance instructions including installation details, leveling requirements, and a statement of Project-specific requirements and instructions, for the filter underdrain system.

B. Informational Submittals:

1. Written confirmation that filter media is compatible with underdrain system.
2. Test reports showing conformity with hydraulic and pneumatic flow. Address full range of flow conditions
3. Certification that filter underdrain system will satisfy specified hydraulic and pneumatic conditions and provide even distribution of air, water, and combined air/water flow at specified flow rates as fed in arrangement shown on Drawings.
4. Design calculations showing structural design requirements, including anchor bolt sizing. Structural calculations shall be stamped and signed by structural engineer registered in state of the Project.
5. Documentation showing NSF 61 certification of underdrain components, including sealing compounds, caulks, and other materials.
6. Proposed method of testing installed system.

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7. Field Test Reports: Describe units tested, type of test, test set ups, procedures, instrumentation, flow rates, pressures, levels, and other data and results as required to demonstrate items tested meet specified requirements.
8. Certificate of factory tests and test results prior to delivery of underdrain system components.
9. Delivery, storage, handling, installation, field testing, operating, and maintenance instructions including installation details, leveling requirements, and a statement of Project-specific requirements and instructions, for the filter underdrain system.
10. Manufacturer's installation instructions and details.
11. Manufacturer's written confirmation filters have been satisfactorily prepared for installation of filter underdrain system.
12. Manufacturer's Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers' Field Services.
13. Operation and Maintenance Data as specified in Section 01 78 23, Operation and Maintenance Data.

1.05 QUALITY ASSURANCE

A. Qualifications:

1. Manufacturer shall have, as a minimum, 15 successful installations in the United States of a complete underdrain system.
2. Manufacturer's representative for field services shall be a direct employee of filter underdrain system manufacturer and shall have minimum of 5 years' experience installing type of underdrain system specified herein.

B. Certification: Materials used in contact with water and backwash air shall meet NSF 61.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Equipment shall be boxed, crated, or otherwise protected from damage and moisture during shipment, handling, and storage and adequately marked for ease of erection.

B. Equipment shall be protected from exposure to corrosive fumes and kept dry.

C. Store products in a manner that prevents damage and in an area that is protected from the weather.

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1.07 SPECIAL GUARANTEE

A. Provide manufacturer's extended guarantee or warranty, with Owner named as beneficiary, in writing, as special guarantee. Special guarantee shall provide for correction, or at the option of the Owner, removal and replacement of underdrain material found defective during a period of 5 years after the date of Substantial Completion. Duties and obligations for correction or removal and replacement of defective Work shall be as specified in the General Conditions.

PART 2 PRODUCTS

2.01 DUAL LATERAL BLOCK FILTER UNDERDRAIN SYSTEM

A. Manufacturers:

1. Where a manufacturer's standard equipment name or model number is listed, equipment system shall be provided as modified to conform to performance, functions, features, and materials of construction as specified herein.
2. Materials and products specified herein shall be selected and supplied by filter underdrain system manufacturer, unless specified otherwise.
3. Materials, equipment, and accessories specified in this section shall be products of:
   a. F.B. Leopold Co., Inc., Zelienople, PA; Universal® Type XA® Underdrain with IMS® cap.
   b. Leopold Wash Trough and Media Retaining Baffles.
4. No "or-equal" or substitute products will be considered.

B. Underdrain Blocks:

1. Dual lateral type whereby parallel feeder and compensating laterals are contained within cross section of a single block.
   a. Cross section shall be arranged so feeder (or primary) lateral is adjacent and connected to compensating (or secondary) laterals through a series of orifices.
   b. Discharge of flow from top of block shall be controlled by orifices that provide uniform distribution of water during filtration and backwash.
   c. Feeder lateral shall have cross-sectional area of at least 50 square inches per block to achieve acceptable air and water transport velocities and head losses during backwash.
2. Distribution Orifices:
   a. Sized and located to provide uniform distribution of water and air.
      1) Not less than 7/32-inch diameter and shall be recessed from the surface by approximately 1/8 inch.

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b. Top of each distribution orifice shall be encircled by a depression approximately 3/8 inch by 3/4 inch.
c. Approximately 22 per square foot of underdrain system.

3. Primary Lateral: Vented or baffled to prevent air from remaining in primary lateral during water-only portion of backwash cycle.
4. Individual Blocks:
   a. Impervious, high strength, completely inert, high density polyethylene (HDPE) material.
   b. Resistant to erosion and corrosion.
   c. Uniform, smooth surfaces.
   d. Orifices shall be properly deburred.
   e. Ridges and pockets for structural rigidity and to key into surrounding grout.
   f. Dimensions: 12 inches high by 11 inches wide, maximum, by maximum of 48 inches long.
   g. Size and weight permit ease of handling and installation.
   h. Arranged end-to-end and mechanically joined to form continuous underdrain laterals.
5. Joints:
   a. Gasketed, bell-and-spigot type with internal registers.
   b. Snap-lock type with integral interlocking snap lugs and receptors.
   c. Air and watertight.
   d. Gaskets:
      1) Supplied by underdrain system manufacturer.
      2) Made of neoprene or cross-linked closed cell polyethylene.
   e. Joining technique shall be such that no leakage (air or water) occurs with a maximum 2-degree misalignment at each joint.
6. Flume Blocks:
   a. Provide for entrance or upstream (backwash mode) end of each underdrain lateral.
   b. Accept backwash water from lower gullet wall opening during backwash and provide an equalizing or secondary flume inside filter.
   c. Sized as required to ensure equal flow distribution among laterals.
   d. Discharge filtered water to effluent flume during filtration.
   e. Accept air from air header located in flume from air risers.
   f. Anchors: Provide angles, preshaped anchor rods (e.g., “L-rods”), epoxy adhesive system, concrete anchors, and sealant to anchor flume blocks to filter floor.
   g. Support from gullet wall and seal to gullet wall.
7. End Plates: HDPE sealed to downstream end of laterals at filter wall.
8. Integral Support Cap:
   a. Constructed of HDPE plastic beads sintered together or Type 316 stainless steel.

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b. Pore Size and Volume: Sufficient to prevent media from obstructing or passing through underdrain.
c. Shall not increase overall underdrain height by more than 1 inch.
d. Attached to underdrain at factory with Type 316 stainless steel screws and sealed with manufacturer's recommended caulking.
e. Eliminate need for, and function in lieu of, support gravel.

9. Equipment Flanges: Comply with ASME B16.1, Class 125 or ASME B16.5, Class 150, unless otherwise indicated.
10. Sleeves and Gaskets: Neoprene, 45 to 55 durometer rated for 200 degrees F.
11. The underdrain system, and all components thereof, shall be compatible with the filter media which is being supplied under a separate contract. Section 44 43 30, Filter Media, describes the filter media.
    a. The filter media will consist of, from bottom to top, a 12-inch layer of silica sand followed by a 48-inch layer of granular activated carbon.

2.02 SERVICE CONDITIONS

A. Filter underdrain system shall operate in dual media (granular activated carbon and silica sand), deep bed, gravity water treatment filters.

B. Backwashing regime for filters uses air scouring and includes air only, combined air/water, and water-only steps.

C. Filter Influent:

1. Will be settled water/clarified water from the flocculation and sedimentation process. Filter influent water will enter each filter through the filter influent channel.
2. Filter influent will contain low concentrations of sodium hydroxide and anionic polymer from upstream processes.
3. Filter influent will not be chlorinated.
4. Influent will have turbidity less than 3 NTU.

D. Filter backwash water will be filter effluent supplied from clearwell 1 milligram per liter of chlorine.

E. Temperature:

1. Filter influent and backwash water are expected to be approximately 55 degrees F to 70 degrees F.
2. Air scouring air at filter air scour header shall not exceed 275.

F. pH ranges of filter influent and backwash water are expected to be approximately 6 pH units to 8.5 pH units.

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2.03 FILTER AIR SCOUR HEADER AND RISER ASSEMBLIES AND ACCESSORIES

A. The filter air scour header and riser assemblies and accessories shall be designed by the filter underdrain system manufacturer.

B. Design each filter with air scour piping to provide uniform distribution of air during backwash.

1. Each assembly shall include air scour header and risers as shown on Drawings.
2. Materials of Construction: Headers and risers shall be Schedule 5 or 10, Type 316 stainless steel pipe.

C. Provide sleeves, couplings, and miscellaneous hardware to connect drop legs to flume block, as applicable.

D. Provide pipe supports/restraints, concrete anchors, and miscellaneous hardware (for example, fasteners) for header and drop pipes. Metallic components shall be Type 316 stainless steel.

E. Equipment Flanges: Comply with ASME B16.1, Class 125 or ASME B16.5, Class 150, unless otherwise indicated.

2.04 ANCHOR BOLTS

A. Anchor Bolts: As specified in Section 05 50 00, Metal Fabrications.

2.05 GROUT

A. As recommended by underdrain manufacturer.

2.06 CONCRETE

A. As specified in Section 03 30 00, Cast-in-Place Concrete.

2.07 REINFORCING STEEL

A. As specified in Section 03 21 00, Steel Reinforcement.

2.08 SPECIAL TOOLS

A. Provide special tools and lubricants needed to install underdrain system.

2.09 FABRICATION

A. Metals below top of filter box wall shall be Type 316 or Type 316L stainless steel as appropriate. Hot dipped galvanized steel shall not be acceptable.

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B. Metallic components shall be premanufactured (for example, concrete anchors) or shop fabricated (for example, air scour header assemblies) components. Field fabrication, bending, cutting, or welding shall not be acceptable.

C. After fabrication, pickle and passivate stainless steel assemblies and parts according to ASTM A380.

2.10 SOURCE QUALITY CONTROL

A. Prior to shipment from factory, test one out of every 400 blocks, with integral support caps, for head loss and uniform distribution of air and water. Results of tests shall be within 10 percent of manufacturer's published values.

PART 3 EXECUTION

3.01 EXAMINATION

A. Prior to commencement of installation of underdrain system, manufacturer's representative shall inspect filter preparation work and provide written confirmation that filters are satisfactorily prepared for the installation of air scour and underdrain system.

3.02 INSTALLATION

A. General: Install in accordance with manufacturer's instructions, recommendations, and interface requirements with surrounding structures, including requirements for grouting keys and pockets, dowels, support ledges and piers, anchorage.

B. Cleaning:

1. Remove debris and sand from filter gullets and power wash inside of gullet.
2. Take precautions recommended by underdrain manufacturer or specified herein to ensure filter underdrain system and associated piping and conduits are completely clean and free of debris, dirt, or other foreign materials which could clog underdrain system or interfere with flow.
3. Flush backwash air piping and recessed flume.
4. Remove loose debris and dirt within filter cell and flume by brooming down and vacuuming.
5. CH2M HILL's Engineer and filter underdrain manufacturer's representative shall approve cleaning before Subcontractor may begin placement of filter media.

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C. Protection:

1. As installation progresses, protect partially completed portions of the Work to maintain cleanliness of underdrain system.
2. Maintain protection until media is installed.

D. Dual Lateral Block Filter Underdrain System:

1. Do not use blocks with warped surfaces or uneven orifices, or blocks that are cracked or otherwise damaged.
2. Set blocks level in fresh grout over entire bottom.
3. Spaces between blocks of adjoining underdrain laterals and spaces between underdrain lateral and filter box walls shall not exceed 3 inches.
4. Exercise care in preparing filter floor slab and in setting anchors to ensure proper alignment and elevation. Consult with manufacturer on level tolerance of filter slab. Screen slab to flat level plain and be free from protrusions and depressions.
5. Install plates and gaskets at ends of each row of blocks.
6. Locate gaskets at expansion joints and couplings to form airtight connection.
7. Install anchor rods.
8. Flume blocks shall not be modified in field except under direct supervision of manufacturer's representative.
9. Grout:
    a. After blocks have been set and carefully aligned, grout spaces between rows and ends of blocks and walls.
    b. Prevent grout from entering laterals, orifices, integral support cap pores, or from being deposited in a manner that would interfere with distribution and dispersion of flow.
    c. Cure for minimum of 3 days before placing filter media or performing backwash tests.

E. Grout:

1. Place and cure grout as directed by grout and underdrain manufacturers.
2. Keep grout out of orifices and flow passages and prevent grout from being deposited where it could interfere with flow.

3.03 TESTS AND INSPECTIONS

A. Perform backwash and filtration tests on completed system following installation of underdrain system, curing of concrete and grout, and prior to placing filter media.

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B. Perform tests in both filtration (downflow) and backwash (upflow) modes at specified rates to confirm hydraulic performance is in compliance with this section.

C. Check for and correct leaks and nonuniform flow of backwash water and air, structural instability, or other defects.

D. During backwash test, visually observe for signs of dead spots or boils. Evidence of flow maldistribution such as a water “mound” or “boil” in filter will constitute a failed test.

E. If defects require correction, retest as necessary until results are acceptable to CH2M HILL’s Engineer.

F. Test Report: State results of tests, procedures used, details of adjustments made to unit, and precautions to be taken to ensure proper and safe operation and maintenance of unit.

G. Filter underdrain system manufacturer’s representative shall not furnish a Certificate of Proper Installation until representative is satisfied filter underdrain system has been properly installed and functionally tested and that detrimental effects of subsequent filter media placement have been remedied.

3.04 MANUFACTURER’S SERVICES

A. See Section 01 43 33, Manufacturers’ Field Services, and Section 01 91 14, Equipment Testing and Facility Startup.

END OF SECTION

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SECTION 44 44 13
CARBON DIOXIDE STORAGE TANK SYSTEM

PART 1 GENERAL

1.01 DESCRIPTION

A. This section covers the work necessary to furnish the equipment and materials required for the carbon dioxide storage system. The system, as specified herein, shall be furnished by one supplier, with at least 5 years of prior experience in supplying polyurethane insulated carbon dioxide systems.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Society of Mechanical Engineers (ASME):
   a. ASME BPV Code Section VIII, Division 1, Rules for Construction of Pressure Vessels.
   b. ASME BPV Code Section IX, Part QW, Welding Qualifications.
2. American National Standards Institute (ANSI): B31.1 and K61.1 requirements.
3. American Welding Society (ANSI/AWS):
   a. D1.1-94, Structural Welding Code—Steel.
   b. QC1-99, AWS Standard for Certification of Welding Inspectors.
4. Compressed Gas Association (CGA) Pamphlet G-6.1, Standard for Insulated Liquid Carbon Dioxide Systems at Consumer Sites.
5. Occupational Health and Safety Administration (OSHA).
6. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).
7. UL: 508A, Standards for Safety, Industrial Control Panels.

1.03 WORK OF THIS SECTION

A. The Work of this section includes providing carbon dioxide storage tank system inclusive of liquid vaporizer, vapor heater, refrigeration system, piping, valves, instrumentation and all appurtenant work.

B. Unit Responsibility: The Work requires that the carbon dioxide storage tank system complete with all accessories and appurtenances be the end product of one responsible system manufacturer or responsible system supplier. Unless otherwise indicated, the Contractor shall obtain each system from the responsible supplier of the equipment. The CO_2 storage tank system supplier shall furnish and/or coordinate all components and accessories as necessary to place the equipment in operation in conformance with the specified

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performance, features, and functions indicated without altering or modifying the Contractor's responsibilities under the Contract Documents. The Contractor is responsible to the Owner for providing the equipment systems as specified herein and installing per the Contract Documents. Overall dimensions and equipment layouts are based on equipment provided by TomCO_2 Systems. Contractor is responsible for coordinating required changes to Work if alternate equipment is supplied.

C. General Requirements: See Division 1, General Requirements, which contains information and requirements that apply to the work specified herein and are mandatory for this Project.

D. Electrical Requirements: Design and provide equipment suitable for the NEC classification per Division 26, Electrical.

E. Instrumentation and Controls: Refer to Section 40 90 00, Instrumentation and Control for Process Systems.

1.04 DEFINITIONS

A. CO_2: Carbon dioxide.

1.05 SUBMITTALS

A. Action Submittals:

1. Complete catalog information, descriptive literature, specifications, identification of materials of construction of major system components, including vaporizer, vapor heater, refrigeration unit, and valves/actuators.
2. Detailed dimensional drawings of equipment and skid-mounted assemblies, including mounting requirements and piping connection sizes and locations.
3. Complete piping schematic drawings showing gas and liquid piping, valves, instrumentation, appurtenances and flows directly associated with storage tank.
4. Complete bill of materials of equipment, instruments, devices, and valves provided, including tag numbers matching as shown on Contract Drawings.
5. Shop and field welding procedure specifications and supporting welding procedure and inspection qualification records.
6. Make, model, weight, and horsepower of major system components.
7. Power and control wiring diagrams, with uniquely numbered power and control terminal blocks.
8. Complete motor nameplate data, as defined by NEMA, motor manufacturer, including any motor modifications.

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9. Manufacturer's material compatibility information, confirming compatibility of parts in contact with wetted parts or dry chemical.
10. Factory finish system.

B. Informational Submittals:

1. Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing. Anchor calculations shall account for edge distance, concrete thickness, and other existing conditions which shall be field verified by the Contractor and identified in the calculations and any related Drawings.
2. Factory Test Reports including certified tank welding inspection results.
3. Credentials and statement of qualifications for tank welder and welding inspector.
4. Functional Test Reports.
5. Performance Test Reports.
6. Manufacturer's Certification of Compliance.
7. Manufacturer's Certificate of Compliance that tank is certified and stamped in accordance with ASME Section VIII, Division 1.
8. Manufacturers Certificate of Proper Installation in accordance with Section 01 43 33, Manufacturers' Field Services.
9. Special shipping, storage and protection, and handling instructions.
10. Manufacturer's printed installation and startup instructions.
11. List of suggested spare parts to maintain equipment in service for a period of 1 year and 5 years with currents.
12. List spare parts furnished with equipment including part numbers.
13. Name and contact information of local suppliers for spare parts.
14. Operation and Maintenance Manuals in accordance with Section 01 78 23, Operation and Maintenance Data, including process narrative describing routine operation of system.

1.06 QUALITY ASSURANCE

A. Qualifications: The CO_2 storage tank system supplier shall have at least 10 years' experience in the design, installation, and operation of ASME certified carbon dioxide storage tank systems. A minimum of ten installations of comparable size (greater than 5 tons capacity CO_2 storage tank) shall be in successful operation for at least the past 5 years.

1.07 SPARE PARTS AND SPECIAL TOOLS

A. Furnish, tag, and box for shipment and storage all spare parts and special tools provided for the carbon dioxide system. The spare parts shall, if possible, be enclosed within an airtight membrane.

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B. Furnish one year supply of lubricants including oil and greases, as recommended by the product manufacturer in original sealed containers correctly identified as to brand and grade with reference to the particular piece(s) of equipment for which it is intended. The lubricants shall include summer and winter grades along with alternative references to equal products of other manufacturers, including specifications such as AGMA numbers and viscosity.

C. Provide a complete set of special tools required to service the equipment system.

D. Furnish the following spare parts:

1. Carbon Dioxide Storage System:
   a. One vaporizer heating element.
   b. One pressure switch.
   c. Two manual isolation valves.
   d. Three fuses for vaporizer.
   e. Two fuses for vapor heater.
   f. Three fuses for refrigeration system.

1.08 WARRANTY

A. Provide as specified in the Standard Provisions. Warranty shall be valid for 1 year beginning on the date of final acceptance.

PART 2 PRODUCTS

2.01 MANUFACTURER

A. Materials, equipment, and accessories specified in this section shall be the product of:

1. TOMCO2 Systems, Loganville, GA.
2. BlueInGreen, LLC, Fayetteville, AR.
3. “Or-equal.”

2.02 MATERIALS

A. All pipes, valves, and fittings shall be Schedule 80 Type 304L stainless steel with screwed fittings, unless otherwise specified. All other equipment called out as stainless steel shall be Type 304L, unless otherwise specified. [DM1]

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2.03 GENERAL

A. The installed carbon dioxide system shall include, but is not limited to, the following items:

1. One (1) Horizontal 6 ton Storage Vessel.
2. One (1) 3 kW electric vaporizer/pressure building unit (480 volt, three-phase, 60-Hz).
3. One (1) Vapor Heater with thru-the-door disconnect (2 kW, 480 volt, single-phase, 60-Hz).
4. One (1) First stage pressure regulator.

B. Ambient Temperature Range: Minus 10.5 degrees F to 104.6 degrees F outdoor.

2.04 LIQUID CARBON DIOXIDE STORAGE TANK

A. One carbon dioxide storage tank shall be provided, each complete as described below.

B. The storage tank shall consist of a welded steel pressure vessel designed and constructed in accordance with Section VIII, Division 1 of the ASME "Code for Unfired Pressure Vessels". The tank shall be designed for a maximum allowable working pressure of 350 psig at 200 degrees F. Minimum design metal temperature for the vessel shall be minus 40 degrees F. The pressure vessel shall be fabricated from ASME SA612, Grade B carbon steel.

C. The storage tank shall be horizontal orientation and capable of holding up to 12,000 pounds of liquid carbon dioxide (6 ton) at 300 psig and 0 degree F.

D. The tank shall be insulated with a minimum of 4 inches of polyurethane foam insulation with a pre-painted white aluminum shell. The ends are to be covered with aluminum preformed flanged and dished heads. The thermal conductivity (overall U-factor) for the insulated tank wall shall not be greater than 0.04 Btu per hour per square foot per degree F.

E. The storage tank shall be complete with a liquid level transmitter calibrated to read tank contents in pounds of CO_2. A 4 mA to 20 mA analog signal shall be provided for transmission of the liquid level (inches) in the storage tank.

F. Tank shall have a 0 psig to 600 psig local pressure gauge for measurement of the pressure (psig) in the storage tank.

G. The storage tank shall be protected from being subjected to pressures greater than the maximum allowable working pressure by means of two ASME approved safety relief valves operating in conjunction with a three-way switching valve, local pressure indicator, and two bleeder type relief valves.

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H. The tank shall be provided with pressure switches to sound an alarm automatically in the event of excessive high or low pressure in the tank. The alarm horn and indicating lights shall be mounted on the control panel located by the storage tank. The panel shall be complete with an alarm silence circuit to shut off the audible alarm. Contacts shall be provided for remote indication of high and low tank pressure alarm.

I. Tank shall have all necessary pipe connections for filling and withdrawal of CO_2 from the storage tank, as shown on Contract Drawings.

J. All nozzles on the vessel shall be seamless Schedule 80 stainless steel, rated for the design pressure of the tank as a minimum. Provide Class 300 rated flanged fittings for connections 2 inches or larger.

K. All piping and fittings provided as a part of the storage tank system shall be seamless Schedule 80 stainless steel, with 2,000 psi rated screwed fittings where used.

L. Stainless steel ball valves shall be provided where the connections for the liquid fill, vapor return, tank-to-tank liquid CO_2 connection and vapor process lines connect to the tank, and where needed to remove and service the ancillary equipment without emptying the tank.

1. Two-piece, standard port, NPT threaded ends, ASTM A351/A351M GR CF8M stainless steel body and end pieces, actuator mounting pad, Type 316 stainless steel ball and stem, self-relieving seat, reinforced TFM seats and seals, adjustable packing nut, blowout-proof stem, rated 2,000 psig WOG minimum, 150 psi SWP, complies with MSS SP-25. Compatible for carbon dioxide gas service.
    a. Manufacturers and Products:
        1) Jamesbury; Eliminator Model B.
        2) “Or-equal.”

M. All connections intended for filling the tank shall be CGA fitting type with cover. Liquid fill line shall be a minimum of 1-1/2 inch diameter. Vapor return line shall be 1 inch diameter.

N. The storage tank system shall be provided with an enclosure mounted directly to the storage tank, which shall provide weather protection for the mechanical equipment. The enclosure shall consist of a structural frame, which shall be covered with an aluminum sheet of minimum thickness of 0.04 inches (1 mm).

O. The storage tank system shall be provided with an enclosure mounted directly to the storage tank, which shall provide weather protection for the CO_2 liquid fill and vapor return lines, as shown on the Contract Drawings. The enclosure

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shall consist of a structural frame mounted directly to the storage tank, which shall be covered with an aluminum sheet of minimum thickness of 0.04 inches (1 mm) and include a lockable access door. Minimum width and height shall be 39 inches by 67 inches.

P. Adequate vent area shall be provided to allow cooling air circulation for the refrigeration system and other mechanical equipment. The enclosure shall have an access door to provide access to mechanical equipment.

Q. All outdoor field piping external to the tank and equipment enclosure shall be insulated using Type 3 Foamglass insulation with Type F3 aluminum jacketing, per Section 40 42 13, Process Piping Insulation, requirements.

R. No screwed fittings directly into tank shall are allowed. All fittings shall be welded integral into the tank and rated to meet or exceed the tank shell rating.

S. Dual ASME safety relief valves and dual bleeder relief valves with 3-way switching valves.

T. Single 480 volt, three-phase electrical connection and single CO_2 process connection.

U. NEMA 4X stainless steel electrical panels for the refrigeration unit and vaporizer with circuit breaker disconnects.

2.05 CARBON DIOXIDE REFRIGERATION SYSTEM

A. A complete environmentally safe refrigeration system shall be provided with the storage tank that will automatically maintain the storage tank at 0 degrees F and less than 305 psig.

B. The evaporation coil of the refrigeration system shall be located inside of the top portion of the storage tank, with the compressor and air cooled condensing coil mounted on a frame off the front head of the tank.

C. The refrigeration system shall be equipped with a condensing unit driven by 1 hp, 480-volt, 60-Hz, three-phase compressor and provided with a circuit breaker disconnector switch, motor starter, and a 120-volt control voltage transformer mounted in a NEMA 4X Type 304 stainless steel enclosure.

D. The condensing unit will include a sight glass, refrigerant line, solenoid valve, expansion valve and a refrigeration coil.

E. Automatic controls shall be provided to control the refrigeration system to maintain the tank pressure below 305 psig. An adjustable differential pressure switch shall activate the refrigeration system at 305 psig and shall deactivate the unit at 295 psig. Refrigeration system shall include a NEMA 4X Type 304

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stainless steel control panel which includes tank HIGH pressure alarm indicating light, tank LOW pressure alarm indicating light, and alarm horn triggered upon High or Low tank pressure. An alarm silence button shall also be provided.

F. The refrigeration system shall be pre-piped and pre-wired and located inside the storage tank equipment enclosure. Provide lockable electrical panel door with appropriate safety interlocks.

2.06 CARBON DIOXIDE ELECTRIC VAPORIZER

A. The storage tank shall be equipped with a liquid CO_2 vaporizer and control panel, shall be provided capable of vaporizing at least 20 pounds of liquid carbon dioxide per hour at 300 psig. The vaporizer will include a pressure switch to maintain pressure in the storage tank and a high temperature cut off switch. [DM2]

B. The vaporizer shall be connected to the CO_2 storage tank as an integral component to the storage tank skid. Vaporizer shell shall be designed for same process conditions as tank.

C. Liquid carbon dioxide shall be drawn from the bottom of the tank, with the resulting vapor returning to the top of the tank. Include a purging valve for easy removal of accumulated impurities, safety controls consisting of a safety relief valve, a thermostat for overheat protection and a fused control circuit for coil protection shall be provided.

D. Vaporizer inlet and outlet piping shall be covered with polyurethane insulation followed by a vapor barrier of pre-painted aluminum sheet to match the tank shell material.

E. Electrical requirements shall not exceed 3 kW at 480-volt, three-phase, 60-Hz, and shall be provided with a circuit breaker disconnect switch in a NEMA 4X 304 stainless steel rated enclosure.

F. The vaporizer and control panel shall be supplied pre-piped, pre-wired, and pre-insulated inside the storage tank equipment enclosure. Provide lockable electrical panel door with appropriate safety interlocks.

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2.07 CARBON DIOXIDE VAPOR HEATER

A. The tank shall be provided with a carbon dioxide vapor heater to heat the 0 degree F CO_2 gas to near room temperature at a minimum rate of 20 pounds per hour. The vapor heater shall be rated for operation at 2 kW, 480-volt, single phase, 60-Hz.

B. The vapor heater shall be supplied complete with a “through the door” disconnect switch and electronic temperature control. Operating control range shall be adjustable from 30 degrees F to 110 degrees F. Solid high conductivity aluminum pressure castings containing the electrical resistance heater and aluminum casting containing the stainless steel tubing for the CO_2 vapor shall be provided. An overheat device shall be supplied to shut off the heating element should the temperature reach 200 degrees F.

C. Electrical requirements shall not exceed 2 kW each at 480-volt, single-phase, 60-Hz, and shall be provided with a through-the-door disconnect switch, 304 stainless steel cover.

D. A manual reset button shall be supplied for restarting the heater after the overheat temperature controller has tripped out.

E. The vapor heater enclosure shall be supplied pre-piped and pre-wired in the storage tank equipment enclosure.

2.08 FIRST STAGE PRESSURE REGULATOR

A. A carbon dioxide pressure reducing regulator will be supplied and mounted on the carbon dioxide process vapor pipeline after the carbon dioxide vapor heater. The regulator shall be used to reduce the pressure from approximately 300 psig to 120 psig. The regulator shall have a malleable iron body, aluminum spring case and lower case, nitrile and aluminum valve disc and holder, nylon fabric coated with nitrile diaphragm, stainless steel valve stem and valve stem guide. The outlet pressure of the regulator shall be easily adjusted through the use of an adjustment screw.

B. One pressure gauge complete with isolation valve, shall be provided for indication of the CO_2 pressure downstream of the pressure regulator to allow for setting the pressure on the regulator.

2.09 ELECTRICAL

A. Provide factory-wired internal power distribution, disconnects, and any necessary power supplies or transformers. Single point connection to the control panel shall be provided by others.

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B. Design electrical systems and provide equipment suitable for the NEC classification per Division 26, Electrical.

2.10 ACCESSORIES

A. Equipment identification plates: 16-gauge Type 316 stainless steel with 1/4 inch die-stamped equipment tag numbers securely mounted in readily visible locations.

B. Lifting lugs: Provide lifting lugs on each tank (minimum 2 per tank).

C. Tank Saddle Supports: Tank shall be provided with integral tank saddle supports capable of distributing the tank loads through the base frame to the concrete pedestal supports below, as shown on the Contract Drawings. Two saddle supports shall be provided mounted the I-beam base frame. Contractor is responsible for coordinating the location of the tank saddle supports and concrete pedestals before installation.

D. All exterior tank components shall be protected from freezing through the use of insulation and/or heat tracing.

E. Grounding Lugs: Provide terminals on support legs for connecting tank system to ground.

F. Handle locks: Access doors to CO_2 equipment enclosure shall be provided with lockable handles.

G. Pressure relief valves shall be provided in all sections of the piping that can be isolated.

2.11 INSTRUMENTATION AND CONTROLS

A. General:

1. Provide control devices, instruments and panels in accordance with general control requirements specified in Section 40 99 90, Package Control Systems.
2. The minimum functional requirements of the control system are specified herein. Provide additional instrumentation and controls as to provide and safe and operable system.

B. Operator Controls and Indicators: All controls and indications shall be housed as part of the individual component enclosure. Internal and external panel components shall meet the requirements of Section 40 99 90, Package Control Systems.

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1. Carbon Dioxide Storage Tank:
    a. Carbon dioxide tank differential pressure indicating transmitter.
    b. Tank LOW Pressure alarm.
    c. Tank HIGH Pressure alarm.

C. External Interfaces:

1. As a minimum, the CO_2 storage tank system supplier shall provide the following signal interface with Section 40 90 00, Instrumentation and Control for Process Systems. All signals shall be wired to terminals within the panel. All analog signals shall be 4 mA to 20 mA. Discrete interfaces shall be dry contact closures rated for 3 amps at 120V ac:
    a. Carbon Dioxide Storage Tanks (Set of Signals per each Tank):
        1) Carbon dioxide tanks analog differential pressure.
        2) Carbon dioxide tank high pressure alarm dry contact status.
        3) Carbon dioxide tank low pressure alarm dry contact status.

D. Instruments:

1. Provide as shown in Contract Documents.
    a. Pressure Switches:
        1) Manufacturers/Models:
            a) Ashcroft; B400 series.
            b) Mercoid; D series.
            c) SOR; 401.
            d) Allen Bradley; 836-A4.
            e) “Or-equal.”
    b. Differential Pressure Transmitter:
        1) 316 stainless steel, integral mounted transmitter, loop powered, 4 mA to 20 mA output.
        2) Manufacturers/Models:
            a) Emerso; Rosemount 1151 DP.
            b) Siemens; DS III.
            c) ABB; 264DS.
            d) “Or-equal.”
    c. Pressure Gauge
        1) Black thermoplastic case, glass or acrylic window, SST wetted parts. 4.5-inch or 6-inch diameter. Materials and pressure range suitable for the intended service.
        2) Manufacturers/Models:
            a) Ashcroft; Duragauge Model 1259/1279/1279 PLUS!
            b) Ametek US Gauge; Solfrunt Model 1981 Advantage.
            c) WIKA; Type 2xx.34.
            d) Precision; 6504.
            e) Thuemling-Duro Instruments; Series 20.
            f) “Or-equal.”

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2.12 FACTORY FINISHING

A. The storage tank, tank supports, and other exposed metal surfaces shall be coated in accordance with Section 09 90 00, Painting and Coating.

2.13 SOURCE QUALITY CONTROL

A. Factory Inspections: Inspect control panels for required construction, electrical connection, and intended function, including welding quality.

B. Factory Tests and Adjustments: Test all equipment and control panels actually furnished.

C. Factory Test Report:

1. Include test data sheets.
2. Manufacturer's Certificate of Compliance that tank is certified and stamped in accordance with latest revision of ASME Code.

PART 3 EXECUTION

3.01 GENERAL

A. The manufacturer shall prepare the equipment for shipment and shall be responsible until it is received by the Contractor. All equipment and materials shall be packaged in a manner that will protect the equipment from damage during shipment.

B. Insofar as practical, equipment shall be shipped assembled, ready for installation at the site. Parts and assemblies that are, of necessity, shipped unassembled shall be trial assembled at the factory and marked in a manner to facilitate final assembly in the field.

3.02 INSTALLATION

A. All equipment shall be installed in accordance with the manufacturer's written instructions.

B. A manufacturer's representative shall supervise:

1. Installation and inspection of the equipment. Check for proper mounting, assembly, mechanical adjustment, lubrication, proper control sequencing, general functioning of equipment, and quality of workmanship.
2. Start-up assistance and troubleshooting.

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3.03 FIELD QUALITY CONTROL

A. All field quality control work shall be performed by Contractor.

B. Field Tests:[BM3]

1. Functional Test:
   a. Prior to startup, all equipment shall be inspected for proper alignment, lubrication, quiet operation, overheating, proper connection, gas leaks, and satisfactory performance by means of a functional test. Any unusual noises or leaks detected during functional testing shall be investigated by the manufacturer's representative.
   b. Manufacturer shall inspect all internal control and power wiring connections, verify high and low pressure setpoints, and verify alarm signal generation in local and remote control panels.
   c. All pressure relief valves shall be tested for proper operation at setpoint, or provided with factory test results indicating proper operation at setpoint if field testing is not feasible.
   d. All electrical equipment shall be operated to verify proper operation.
      1) Activation of vaporizer upon low pressure setpoint.
      2) De-activation of vaporizer upon high pressure setpoint.
      3) Activation of refrigeration unit upon high pressure setpoint.
      4) De-activation of refrigeration unit upon low pressure setpoint.
      5) Ability of vapor heater and first-stage pressure regulator to maintain target pressure setpoint.
   e. All instrumentation and control devices shall be verified for proper operation and accuracy including: Proper operation of tank pressure and level gauges and transmitters. Readings on manual gauges should match transmitter readings and match quantity of CO_2 liquid initially delivered to fill the tank within plus or minus 1 percent.
2. Performance Test:
   a. Field performance tests shall be performed on the installed equipment by Contractor, under the direction of the storage tank manufacturer. The tests shall demonstrate compliance with the specified performance, including:
      1) Continuous operation of storage tank, vaporizer, vapor heater, refrigeration unit, and associated controls for a continuous 14 days period without alarm or malfunction, regardless of CO_2 system demand changes.
      2) Record amp meter readings daily.
      3) Record local and remote tank level and pressure daily.

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b. Furnish certified test reports of the field performance tests. A satisfactory field performance test will be appurtenant to final inspection and acceptance of the work.

3.04 MANUFACTURER'S SERVICES

A. A manufacturer's representative for the equipment specified herein shall be present at the site for the minimum person-day' listed for the serviced hereinafter, travel time excluded.

1. 2 person-days, 1 trip, for instructing the Contractor on proper installation, inspection of installation functional testing, performance testing support, completion of Manufacturer's Certification of Proper Installation.
2. 1 person-day, 1 trip, for system training of Owner's personnel.
3. Each person day constitutes 8 hours of actual time spent at the site and does not include travel to and from the site.

B. Startup services and training of Owner's personnel shall be at such times as requested by Contractor and approved by Owner.

C. See Section 01 43 33, Manufacturers' Field Services, and Section 01 91 14, Equipment Testing and Facility Startup.

END OF SECTION

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SECTION 44 44 13.01
CHEMICAL FEED SYSTEMS

PART 1 GENERAL

1.01 DESCRIPTION

A. This section covers the work necessary to provide skid mounted chemical feed systems for application with Sodium Hypochlorite (12.5 percent). The System should include chemical metering pumps and all associated components specified within this section.

B. Only complete metering pump skids with all required components will be considered. The acceptable manufacturers (Supplier) for consideration are:

1. ProMinent.
2. UGSI Chemical Feed.
3. Grundfos.

C. All equipment and products supplied in this section shall conform to Section 01 61 00, Common Product Requirements.

1.02 DEFINITIONS

A. Terminology pertaining to pumping unit performance and construction shall conform to the ratings and nomenclature of the Hydraulic Institute Standards.

1.03 SUBMITTALS

A. General: Administrative, shop drawings, samples, quality control, and contract closeout submittals shall conform to the requirements of Section 01 33 00, Submittal Procedures. All submittal dimensions, calculations, and other information shall be in English units of measure.

B. Action Submittals:

1. Shop Drawings:
   a. Make, model, weight, and horsepower of each equipment assembly.
   b. Complete catalog information, descriptive literature, specifications, and identification of materials of construction for pump, valves, and all components provided by Supplier.
   c. Performance data on pumps, including curves showing flow rate verses pump stroke setting (in percent) at specified maximum speed in strokes per minute and at minimum pump speed.

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d. Pump data sheet confirming pump capacity in gallons per hour and pressure in psig, pumped chemical characteristics, pipe connection sizes, stroke rate, materials, testing requirements, intermediate fluid type, and appurtenances to be provided with pumps.
e. Detailed dimensional drawings for chemical feed skids and all individual components specified in this section, including mounting requirements and piping connection sizes and locations.
f. Action Submittals in accordance with Section 40 99 90, Package Control Systems:
    1) Power, control panel, and control wiring diagrams, including terminals and numbers.
    2) Pump controller descriptive product information, including wiring diagrams.
g. Complete motor nameplate data, as defined by NEMA, motor manufacturer, and including any motor modifications.
h. Manufacturer's materials compatibility information, confirming compatibility of wetted parts with specified pumped chemicals.
i. Factory finish system.
j. Skid weights (dry and wet) and equipment anchoring and installation criteria for design of structural support by CH2M HILL.
k. List of extra materials to be provided as specified in this section.

C. Informational Submittals:

1. Special shipping, storage and protection, and handling instructions.
2. Manufacturer's printed installation instructions. Include detailed lifting plan for hoisting each skid into place with a crane.
3. Suggested spare parts list to maintain the equipment in service for a period of 5 years. Include a list of special tools required for checking, testing, parts replacement, and maintenance with current price information.
4. List special tools, materials, and supplies furnished with equipment for use prior to and during startup and for future maintenance.
5. Informational Submittals in accordance with Section 40 99 90, Package Control Systems, as applicable.
6. Operation and Maintenance Data: As specified in Section 01 78 23, Operation and Maintenance Data.
7. Factory Quality Control Submittals:
    a. Factory Test Plan.
    b. Factory Test Report and Manufacturer's Certificate of Compliance.
    c. Software Documentation.

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8. Field Quality Control Submittals:
    a. Component Test Plan.
    b. Component Test Report and Manufacturer's Certificate of Proper Installation.

PART 2 PRODUCTS

2.01 SYSTEM DESCRIPTION

A. Sodium Hypochlorite (12.5 percent) will be applied at four locations at the feed rates shown here:

1. RAS/UV/Filters:
    a. Minimum Feed Rate: 0.4 gallons per hour (gph).
    b. Maximum Feed Rate: 41.4 gph.
    c. Maximum Discharge Pressure: 50 psi.
    d. Inlet/Outlet Orientation: Left.
2. Plant Water:
    a. Minimum Feed Rate: 0.26 gph.
    b. Maximum Feed Rate: 3.97 gph.
    c. Maximum Discharge Pressure: 120 psi.
    d. Inlet/Outlet Orientation: Right.

B. For each application, provide one skid-mounted chemical feed system consisting of a duty and standby feed pump and all associated manual valves, strainers, piping, supports, unions for easy equipment removal, flushing connections, calibration columns, pulsation dampeners, pressure elements and switches, pressure safety valves and local control panel as specified herein.

C. Each chemical feed skid shall be completely assembled, mounted, wired, calibrated, tested, and delivered to the site. All components of the skid-mounted system (pump, piping, instruments, fittings and controls) shall be assembled and tested at the Supplier's facility prior to shipment.

D. All materials on skid shall be compatible with Sodium Hypochlorite (12.5 percent). Every component used on each chemical feed system shall be chemically compatible with the chemical used.

1. Any ball valves supplied as part of the skid shall be vented for service with Sodium Hypochlorite (12.5 percent).

E. One 120V, 20A, single-phase power feed will be provided to each pump skid by Division 26, Electrical. Control wiring required between each skid and the plant control system PLC provided under Division 26, Electrical. Wiring on the skid provided and installed by pump system supplier.

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F. Coordinate pump requirements with drive manufacturer and be responsible for pump and drive requirements.

2.02 PUMP

A. Pumps shall be solenoid-driven or motor-driven, reciprocating, mechanically-actuated diaphragm type.

B. Diaphragm material shall be selected to be compatible with Sodium Hypochlorite (12.5 percent). Diaphragm shall be convex in shape, coordinated with concave head to minimize dead space.

C. Bearings, tapered roller or needle type. Gearing, polished steel or bronze worm type. Mount bearings and internal working parts in weather-resistant gear box with moving parts oil flooded.

D. Lubricant, nontoxic food grade quality.

E. Liquid end shall be physically separated from drive unit by back plate with weep hole creating an air gap. Pump leakage shall be prevented through hydraulically actuated balanced diaphragm design.

F. Pump shall include a bleed valve on head (either auto or manual) that allows entrained air from Sodium Hypochlorite (12.5 percent) chemical to be released from the pump head. Bleed valve system should allow for air release with minimal chemical leakage.

2.03 PUMP OUTPUT CONTROL

A. Manual Stroke Adjustment: Provide manual stroke length adjustment through adjustment knob on unit that provides adjustment accuracy of 1 percent. Adjustment shall be self-locking, and shall be operable whether or not pump is running.

B. Adjustable Speed (Stroke Frequency) Adjustment: Provide adjustable speed operation of pump using DC SCR drive or AC inverter. Coordinate pump motor type with drive unit provided. Drive unit shall include integral or separate control panel with speed indication in percent, LOCAL/OFF/REMOTE selector switch, and manual adjustable potentiometer for adjustment of pump speed when in LOCAL position.

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C. Drive unit shall include integral or separate control panel meeting applicable requirements of Section 40 99 90, Package Control Systems. Minimum requirements include:

1. Control panel NEMA 250 Type 4X, Type 316 stainless steel attached and supported from feed system skid.
2. Operator Indicators and Controls:
    a. Speed indication in percent.
    b. Calibrated pump flow in gallons per hour.
    c. Stroke frequency, stroke length, and stroke counter.
    d. LOCAL/OFF/REMOTE selector switch.
    e. Manual adjustable potentiometer for adjustment of pump speed from 0 percent to 100 percent when in LOCAL position.
    f. Pump RUNNING indicating light.
    g. Drive FAIL indicating light.
    h. RESET pushbutton for reset of all fail conditions.
3. External Interfaces:
    a. Analog Input: Accept 4 mA to 20 mA dc SPEED COMMAND signal for linear adjustment of pump speed from 0 percent to 100 percent when in REMOTE position.
    b. Analog Output: Provide 4 mA to 20 mA dc signal for remote SPEED INDICATION of pump, ranged 0 percent to 100 percent.
    c. Discrete Inputs: Accept dry maintained contact RUN command to operate pump when in REMOTE position.
    d. Discrete Outputs:
        1) Dry contacts rated 5A at 120V ac, for:
            a) Pump RUNNING status.
            b) REMOTE position selected.
            c) Drive FAULT.

2.04 PULSATION DAMPENERS

A. Quantity: One per pump.

B. Single-diaphragm type mounted on discharge piping for pneumatic-hydraulic pulsation dampening. Size for pump stroke volume.

C. Air charging valve and pressure gauge.

2.05 INSTRUMENTATION

A. Pressure Diaphragm Seals:

1. Isolate all pressure gauges from chemicals with pressure diaphragm seals. Project standard shall be Ashcroft.

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2. Nominal model shall be 50-100SS-04T-CF (or CG depending on chemical) with customized diaphragm model number to correspond to size, rating, pipe connections, chemical compatibility, etc.
3. Quantity: One per every pressure gauge.

B. Pressure Gauges:

1. Pressure gauges for pump discharge pressure indication. For matching project standard shall be Ashcroft.
2. Nominal model shall be 45-1279SL-04L 100 (or different range to accommodate higher pressure conditions) with customized gauge model number to correspond to size, rating, pipe connections, range, etc.
3. Quantity: One per pump.

C. Provide stainless steel tag labels for each instrument.

2.06 PIPE

A. All piping shall be compatible with Sodium Hypochlorite (12.5 percent) and designed to meet the intended service pressure.

2.07 CALIBRATION COLUMN

A. Sized and graduated to provide adequate duration and accurate measurement across range of specified flow rates for purpose of calibration. Constructed of clear polypropylene and PVC for all chemical skids.

B. Quantity: One per skid.

2.08 VALVES

A. Manual Isolation Valves:

1. Provide Type V300 ball valves that are compatible with Sodium Hypochlorite (12.5 percent) and capable of meeting the system pressure requirements.
2. Quantity: Provide adequate quantity for suction and discharge isolation of chemical feed system, drainage and flushing of chemical feed system, instrumentation isolation and feed from calibration column.

B. Adjustable pressure relief valve shall be sized and set based upon Supplier's recommendation.

1. Griffco, M-Series Pressure Relief Valves, "or-equal."
2. Materials shall be same as connecting piping.
3. Pressure relief discharge piping shall be directed to a plant drain and shall not be recirculated within the pump skid.

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2.09 SKID

A. Provide one skid per chemical application (two pumps per skid). Skid shall have sufficient lifting eyes to allow for entire skid and all components to be picked and set in place with an overhead hoist. Supplier shall design skid to withstand forces as skid is hoisted overhead by lifting eyes. Skid will not deflect when lifted overhead. Lifting skid overhead by lifting eyes will not require removal of any components from skid, including control panels. Material of skid will be steel, coated with manufacturer standard coating.

2.10 INSTALLATION AND SERVICE CONDITIONS

A. Indoor: All components specified herein will be rated for continuous operation at 60 degrees F to 85 degrees F.

1. Wall Mounted: Skids will be mounted and anchored on wall. Supplier to verify that proposed mounting by CH2M HILL is acceptable.

2.11 ACCESSORIES

A. Equipment Identification Plate: 16-gauge stainless steel with 1/4-inch die-stamped equipment tag number securely mounted in a readily visible location.

B. Device Identification Tags: 16-gauge stainless steel with 1/4-inch die-stamped device tag number securely mounted in a readily visible location for all devices.

C. Lifting Lugs: Provide lifting lugs to allow entire skid to be lifted as one unit in addition to lifting lugs on any individual components of skid weighing over 50 pounds.

2.12 FACTORY FINISHING

A. Equipment shall be coated with manufacturer’s standard coating system, provided it does not discolor in the presence of fumes from specified chemical services.

PART 3 EXECUTION

3.01 FACTORY TESTING AND INSPECTION

A. All major system components shall be factory tested for compliance with the construction and functional requirements specified in this section. Notification shall be provided to CH2M HILL 30 days prior to the start of Factory Testing.

B. CH2M HILL may participate in Factory Testing.

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C. Factory Testing shall include the following:

1. Testing of all control panels to be furnished.
2. Testing of the control system by simulating inputs and verifying control logic steps. Upon completion, and prior to shipping equipment to the site, provide electronic copies of all PLC ladder logic and control programs fully documented and suitable for downloading into the PLCs.
    a. The control system shall be paced through all routine alarm and failure modes to assure that the system has been completely debugged and is free from defects.
3. Verification through a quality control process that all equipment and System components were fabricated to specification, are free from defect, and are ready for shipment.

D. The Factory Test Report shall include, but is not limited to, the testing of the control panels and control logic.

E. Factory Test Report shall be submitted and approved prior to equipment being shipped to site.

3.02 INSTALLATION OF EQUIPMENT

A. Installation of equipment is to be done by Subcontractor, as required and instructed by the Supplier. Ancillary equipment required for installation (to include miscellaneous metals, anchor bolts, and hardware) shall be provided and installed by Subcontractor.

3.03 FIELD TESTING AND STARTUP

A. Field services shall conform to Section 01 43 33, Manufacturers' Field Services, and Section 01 91 14, Equipment Testing and Facility Startup.

B. The Supplier shall provide the services of a trained representative to provide installation consultation, testing/startup services, and operation and maintenance training for the Owner's personnel. Representative shall check for proper mounting, assembly, mechanical adjustment, lubrication, proper control sequencing, general functioning of equipment, and overall quality of workmanship prior to starting Component Testing. The Supplier's representative shall approve the installation and provide a Certification of Proper Installation that the system components have been installed correctly and are ready for operation.

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C. Component Testing:

1. Proposed Component Testing procedure shall be developed by the Supplier with input from CH2M HILL. The Component Testing shall include:
   a. Automatic START/STOP and flow control of System in both LOCAL and REMOTE modes.
   b. Automatic System shutdown and startup in response to changes in flow rate.
   c. Automatic System shutdown and alarm in response to each failure condition.
   d. Operation of System with proper control for a continuous 30-minute period during simulated operating conditions.
   e. Monitoring and control from Plant SCADA system.
   f. Operation of all monitoring instruments.

END OF SECTION

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SECTION 44 44 37
VERTICAL SHAFT MIXER

EQUIPMENT AND COMPONENT NUMBER(S)

_____: Rapid Mix Basin 1, Mixer 1.
_____: Rapid Mix Basin 1, Mixer 2.
_____: Rapid Mix Basin 2, Mixer 1.
_____: Rapid Mix Basin 2, Mixer 2.
_____: Flocculation Basin 1 Mixer 1.
_____: Flocculation Basin 1 Mixer 2.
_____: Flocculation Basin 1 Mixer 3.
_____: Flocculation Basin 1 Mixer 4.
_____: Flocculation Basin 1 Mixer 5.
_____: Flocculation Basin 1 Mixer 6.
_____: Flocculation Basin 2 Mixer 1.
_____: Flocculation Basin 2 Mixer 2.
_____: Flocculation Basin 2 Mixer 3.
_____: Flocculation Basin 2 Mixer 4.
_____: Flocculation Basin 2 Mixer 5.
_____: Flocculation Basin 2 Mixer 6.

PART 1 GENERAL

1.01 WORK OF THIS SECTION

A. General: The Work of this section includes providing the Pre-Treatment mixers and all appurtenant work.

1.02 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. American Gear Manufacturers Association (AGMA)
2. National Electrical Manufacturers Association (NEMA)
3. Occupational Safety and Health Administration (OSHA) standards.
4. American Water Works Association (AWWA)

1.03 SUBMITTALS

A. Action Submittals:

1. Detailed Shop Drawings.
2. Make, model, weight, and horsepower of each equipment assembly.
3. Complete catalog information, descriptive literature, specifications, and identification of materials of construction.

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4. Detailed calculations to substantiate all components of mixer selections are adequately sized to impart specified velocity gradient and withstand hydraulic forces during operation.
5. Motor data in accordance with requirements of Section 26 20 00, Low-Voltage AC Induction Motors.
6. Factory finish system.
7. Submit Shop Drawings, cut sheets, and catalog information as required by Section 01 88 15, Anchorage and Bracing.

B. Informational Submittals:

1. Submit support and anchorage calculations as required by this Specification and Section 01 88 15, Anchorage and Bracing.
2. Special shipping, storage and protection, and handling instructions per Section 01 61 00, Common Product Requirements.
3. Manufacturer's printed installation instructions.
4. List special tools, materials, and supplies furnished with equipment for use prior to and during startup and for future maintenance.
5. Manufacturer's Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers' Field Services.
6. Operation and Maintenance Data as specified in Section 01 78 23, Operation and Maintenance Data.
7. Factory Test Reports
8. Field Test Reports

1.04 WARRANTY

A. Provide as specified in Specification Section 01 61 00, Common Product Requirements.

1.05 SPARE PARTS

A. Furnish one complete set of bearings, seals, and shims. Suitably package in wood or metal box and label all spare parts for long-term storage.

PART 2 PRODUCTS

2.01 GENERAL

A. The use of a manufacturer's name and model or catalog number is for the purpose of establishing the standard of quality and general configuration desired only. Products of other manufacturers will be considered in accordance with the Contract Documents. Manufacturers are listed on supplemental data sheets.

B. Mixers shall be furnished complete with speed reducer, flexible coupling with guard, baseplate, agitator shaft, and impellers.

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C. Safety Devices: The completed work shall include all necessary permanent safety devices, such as machinery guards, emergency stops and similar items required by OSHA, and other federal, state, and local health and safety regulations.

D. Guards: All rotating parts above the mounting level must be provided with guards in accordance with OSHA Standards.

2.02 OPERATING CONDITIONS FOR VERTICAL MIXERS

A. Operation: 24 hours per day under moderate to high shock loads.

B. Installed outside with no protection from elements. Ambient temperature range from 0 degrees F to 105 degrees F in full sunlight.

C. Solution to be mixed (process water): pH adjusted with sulfuric acid to a pH of 6 to 7 and coagulated water with ferric chloride concentration of 20.0 mg/L to 40.0 mg/L. Process fluid temperature range from 4 degrees F to 80 degrees F.

D. Process fluid flow rate range: 0.51 MGD to 2.81 MGD for per basin.

2.03 VERTICAL MIXERS

A. Mixer shall include speed reducer, motor with coupling, guard, pedestal and baseplate. The mixer shall also include shaft coupling, mixer shaft, and impellers. Type of shaft coupling identified on supplemental mixer data sheets.

B. Mixer shall be the top-entering type, equipped with motor mounting and gear reducer. Motor shall be connected to the gear reducer by a suitable flexible coupling, and shall be supported from the mixer housing to form an integral unit.

C. Drive housing shall be constructed of cast iron or of welded steel construction. Fabricated housings must be stress relieved before machining. Housing shall be of sufficient rigidity to prevent damaging misalignment when subjected to mixer assembly peak combined torsional, thrust, and bending forces.

D. Pedestal and Mixer Mount: The mixers shall be provided with a pedestal and base plate which elevates the low speed coupling and oil drain above the mounting elevation.

E. All components of mixers, including anchorage, shall be designed to accommodate hydraulic forces during operation based on maximum flow rate at mixer.

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F. The units shall be designed to transmit to the water the indicated velocity gradient "G" based on the design water temperature indicated above at a minimum shear. See attached supplemental schedule for minimum and maximum velocity gradients required for each mixer.

G. Drive: Mixers identified to be adjustable speed on attached schedule shall be driven by a heavy-duty, premium high-efficiency, Totally Enclosed Fan Cooled (TEFC) electric motor coupled to the gear reducer by means of a flexible coupling, and suitable for operation on a 460V three-phase power supply.

H. Each drive assembly shall be of ample capacity to supply the required power and torque output at all speeds across the required speed range. Motor and gear reducer shall be equipped with lifting lugs. Motors shall meet requirements of Section 26 20 00, Low Voltage AC Induction Motors.

1. Motor speed shall not exceed 1,800 RPM.
2. Enclosure Type: TEFC.
3. Supply power shall be 460V, three-phase, and 60-Hz.
4. See attached supplemental schedule for motor sizing. Supplier to confirm or modify specified motor size provides sufficient mixing energy.
5. Mixers identified to be adjustable speed on attached data sheets shall have motors rated for inverter duty.

I. Gear Reducer: Only gear reducers designed and manufactured by the mixer supplier shall be acceptable. Each gear reducer shall be of the horizontal right-angle or vertical offset shaft arrangement type, ruggedly encased in a cast iron or fabricated steel heavy duty housing designed for the conditions it will encounter. Gears shall be helical or spiral bevel type or a combination of both. Worm gear arrangements will not be acceptable. Motor mounted pinions are not acceptable. The reducer shall be designed and manufactured in accordance with the AGMA Standard and shall have a service factor of 1.5 based upon the full motor nameplate horsepower at maximum operating speed. Bearings shall be greased- or oil-lubricated with a minimum L-10 life of 100,000 hours, sufficiently sized to stabilize the impeller assembly under all operating conditions. Gear reducer output shall be equal or greater in diameter than the mixing shaft.

J. Setting: Each drive assembly shall be furnished as a unit, with a pedestal type mounting base with square footplate for mounting to the supporting structure. The pedestal type mounting base shall be provided by the Manufacturer and shall facilitate oil changes and elevate the gear reducer output shaft coupling above the mounting surface. Lifting lugs shall be provided on the motor and gear reducer. The unit shall be self-supporting. No auxiliary motor supports shall be required.

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K. Lubrication: Lubrication of each speed reducer shall be by means of an efficient oil splash mechanism. The drive shall be provided with a dip stick to observe oil level. Each drive must have an effective drywell feature to eliminate oil leakage down the output shaft. Output shaft bearings may be grease lubricated, including a high quality lip seal to retain grease. All oil fill and drain lines and grease fittings shall be in easily accessible locations, at a minimum of 10 in above the mixer mounting surface. All lubricated items must be located in leak proof enclosures. Only food grade oil shall be used.

L. Impeller and Shaft: Mounted at the end of each mixer shaft shall be a stainless steel impeller bolted to a cast or fabricated hub. All submerged nuts, bolts, and washers shall be Type 316 stainless steel. The hub shall be of sufficiently large diameter, and impellers shall be designed to assure maximum efficiency by preventing central backflow. The impeller assembly shall be securely keyed to the shaft. Shaft stresses shall be limited to 9,000 psi and impeller stresses to 12,000 psi. See attached supplemental schedule for minimum impeller and shaft diameters.

M. Shaft length shall be based upon impeller and mixer mounting elevations called out on Drawings.

N. Impeller Adjustment: The impeller shaft shall be of Type 316 stainless steel. The impeller shall be connected to the shaft with a hook key for security. An extended keyway shall be provided to allow for vertical adjustment of each impeller in 3-inch increments plus or minus 12 in from its recommended position.

O. Shaft Coupling: The lower mixer shaft shall be connected to the upper, or drive output shaft, by means of a rigid flanged coupling, of either the welded or interference fit hub type. Mating coupling faces shall have a rabbeted male and female pivoted connection for accurate concentricity, and shall not require match marks for alignment. The coupling shall be designed to minimize shaft run-out, and it shall be located near the tank deck level.

P. Structural Strength and Stability: Structural members and connections shall be designed to withstand, within normal working stresses and deflections, all loads imposed on them by rotation of the assembly at maximum design speeds submerged and dry, as well as loads which may be superimposed during or subsequent to erection while the basins are empty. The shaft shall be designed for a maximum stress not to exceed 11,000 psi while under maximum operating loads. The shaft shall be of the overhung design and the use of bottom steady bearings shall not be permitted. The shaft impeller design shall be such that the operating speed shall not exceed 70 percent of the first lateral critical speed. Lower shaft straightness, rigid coupling squareness, and output shaft accuracy shall give a maximum runout at the lower end of the shaft of

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1/8 inch for every 10 feet of overhang, as measured when turning over by hand.

Q. See Drawings for dimensions and volume to be mixed.

R. Mixers shall pump in an axial direction. See attached supplemental schedule for pumping direction and process fluid direction.

S. Materials:

1. Mixer shaft, impeller, and any submerged supports shall be ASTM A941 316L stainless steel. No painting or coatings are necessary on stainless steel surfaces.
2. The base plate, support frame, motor, and other ancillary items shall be ASTM A897 ductile iron or ASTM A48 cast iron. The ductile iron or cast iron surfaces shall be epoxy coated in accordance with AWWA C210 with NSF 61 certified coating.

2.04 APPROVED MANUFACTURERS

A. General: Meurer Research, Inc., Golden, CO.

B. All mixers shall be manufactured by the same company.

2.05 ACCESSORIES

A. Equipment Identification Plates: Furnish 16-gauge Type 316 stainless steel identification plate securely mounted on each separate equipment component and control panel in a readily visible location. Plate shall bear 3/8-inch-high engraved block type black enamel filled equipment tag number. Equipment tag number shall be as shown in this Specification and as shown on Drawings.

B. Lifting Lugs: Equipment weighing over 100 pounds.

C. Anchor Bolts: Type 316 stainless steel. If sized by equipment manufacturer, 1/2-inch minimum diameter, and as specified in Section 05 50 00, Metal Fabrications.

2.06 FACTORY TESTING

A. Each flocculation unit shall be subjected to a functional factory test by the Manufacturer of the units.

1. Test rotation and vibration within the design RPMs.
2. Re-balance mixer and motor as needed to minimize vibration.
3. The mixer shall operate smoothly, without overloading, jamming, or excessive noise or vibration during normal speed.

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PART 3 EXECUTION

3.01 FIELD TESTING

A. Prior to acceptance of each mixer installation, demonstrate proper operation for a period of 3 hours.

3.02 MANUFACTURER'S SERVICES

A. Manufacturer's Representative:

1. Present at Site or classroom designated by Owner, for minimum person-days listed below, travel time excluded:
   a. One trip for 2 person-days for installation assistance and inspection.
   b. One trip for 2 person-days for field testing, completion of Manufacturer's Certificate of Proper Installation, and training. Training shall not commence until an accepted detailed lesson plan for each training activity has been reviewed by Engineer and Owner.

B. See Section 01 43 33, Manufacturers' Field Services, and Section 01 91 14, Equipment Testing and Facility Startup.

3.03 SUPPLEMENTS

A. The supplement listed below, following "End of Section" is a part of this Specification.

1. Vertical Shaft Mixer Schedule.

END OF SECTION

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Bureau of Reclamation - Cutter Water Treatment Plant - 659925										
44 44 37 - Vertical Shaft Mixers										
Supplement 1 - Vertical Shaft Mixer Schedule										
Name	**Tag Number**	**Velocity Gradient**		**Pumping Direction**	**Pumping Direction**	**Minimum Shaft Diameter**		**Minimim Impeller Diameter**	**Constant / Adjustable Speed**	**Motor Size**
		Maximum	**Minimum**			**Upper**	**Lower**			
		(1/sec)	**(1/sec)**			**(inches)**	**(inches)**	**(inches)**		**(HP)**
Rapid Mix Basin 1 Mixer 1	MXR-280-103-01	500	500	Upward	Downward			18.5	Constant	3
Rapid Mix Basin 1 Mixer 2	MXR-280-103-02	500	500	Downward	Upward			18.5	Constant	3
Rapid Mix Basin 2 Mixer 1	MXR-280-203-01	500	500	Upward	Downward			18.5	Constant	3
Rapid Mix Basin 2 Mixer 2	MXR-280-203-02	500	500	Downward	Upward			18.5	Constant	3
Flocculation Basin 1 Mixer 1	MXR-280-104-01A	60	15	Downward	Transverse			38	Adjustable	0.5
Flocculation Basin 1 Mixer 2	MXR-280-104-01B	60	15	Downward	Transverse			38	Adjustable	0.5
Flocculation Basin 1 Mixer 3	MXR-280-104-02A	40	10	Downward	Transverse			38	Adjustable	0.5
Flocculation Basin 1 Mixer 4	MXR-280-104-02B	40	10	Downward	Transverse			38	Adjustable	0.5
Flocculation Basin 1 Mixer 5	MXR-280-104-03A	20	5	Downward	Transverse			38	Adjustable	0.5
Flocculation Basin 1 Mixer 6	MXR-280-104-03B	20	5	Downward	Transverse			38	Adjustable	0.5
Flocculation Basin 2 Mixer 1	MXR-280-204-01A	60	15	Downward	Transverse			38	Adjustable	0.5
Flocculation Basin 2 Mixer 2	MXR-280-204-01B	60	15	Downward	Transverse			38	Adjustable	0.5
Flocculation Basin 2 Mixer 3	MXR-280-204-02A	40	10	Downward	Transverse			38	Adjustable	0.5
Flocculation Basin 2 Mixer 4	MXR-280-204-02B	40	10	Downward	Transverse			38	Adjustable	0.5
Flocculation Basin 2 Mixer 5	MXR-280-204-03A	20	5	Downward	Transverse			38	Adjustable	0.5
Flocculation Basin 2 Mixer 6	MXR-280-204-03B	20	5	Downward	Transverse			38	Adjustable	0.5

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SECTION 44 44 57
PARALLEL PLATE SETTLER SYSTEM

PART 1 GENERAL

1.01 SECTION INCLUDES

A. This section covers the design, manufacture, delivery, site storage, installation, testing and placement into operation of parallel plate settling equipment.

B. The parallel plate settler system includes but is not limited to plate packs consisting of plates, frames, effluent troughs and weirs, effluent trough connections/extensions, influent baffles, spacers/stiffeners, gaskets, lifting attachments, anchoring systems, and all appurtenances necessary for a complete and operating system.

C. Conform to other related work specified elsewhere.

1.02 GENERAL

A. The parallel plate settler equipment manufacturer shall furnish an engineered system suitable for clarification of coagulated and flocculated water.

B. The manufacturer of the parallel plate settler system shall utilize a fabrication facility regularly engaged in the manufacturing of parallel plate clarification equipment.

1.03 SUBMITTALS

A. Action Submittals:

1. Complete description of the parallel plate settler system, including plate pack support frames, plates, inlet baffles and flumes, outlet weirs and flumes, embedded metal wall connectors, fasteners, and other ancillary items.
2. Plan and section views of the basins, anchor bolt location and templates, dimensional tolerances required for installation. Typical details shall include dimensions of components and their relationship to other items of supply and with respect to the basins and details for sling lifting.
3. A complete listing of materials.
4. Drawings shall include controlling elevations (i.e., V-notch weir, wall openings, bottom of equipment, water surface elevations in the basin and along the effluent trough at minimum and maximum flows).
5. Hydraulic calculations including headloss and velocity through the inclined plate system at minimum and maximum flows.

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6. Embedment design details.
7. The manufacturer shall submit equipment structural support requirements. All structural calculations shall be stamped by a professional engineer registered in the State of **[A:]**.
8. Proof of NSF International (NSF) Standard 61 Certification for Use in Potable Water.

B. Informational Submittals:

1. Installation List: The manufacturer shall submit a list of parallel plate settler systems installed within the last 5 years.
2. Manufacturer's Certificate of Compliance, in accordance with Section 01 61 00, Common Product Requirements, with materials specifications shall be submitted prior to shipment of the equipment. The certificate shall certify that materials, manufacture, and final product conforms to or exceeds specified requirements and intent for which product will be used. Submit supporting reference data, affidavits, and certificates as appropriate. The certificate may reflect recent or previous test results on material or product, acceptable to the Engineer.
3. Operation and Maintenance Data: As specified in Section 01 78 23, Operation and Maintenance Data.
4. Manufacturer's Warranty.
5. Manufacturer's Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers' Field Services.

C. Administrative Submittal:

1. The manufacturer shall provide the following patent warranty and authorization:
    a. Provide a warranty that the proposed use of the parallel plate settler process and equipment is the use for which the system has been expressly designed and sold by the manufacturer. The warranty shall further state that the use will not infringe on any U.S. or foreign patents, and that the necessary licenses have been obtained and are included in the bid price.
    b. Provide written authorization granting the right to use this process and equipment in perpetuity to Owner, and its assigned heirs. This right shall not be subject to any licensing fees, franchising fees, or any other conceivable charge, presented at this time or in the future, that are not included in Contractor's bid price as stated in Bid. Declare in writing that in the event manufacturer ceases to do business under its current registered name, or in the event the manufacturer ceases to be the sole direct licenser of this process and equipment, or in the event this equipment is not available by any reasonable means, Owner, and its assigned heirs have the

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right and authorization to use the process and equipment for unspecified future expansions at the Water Treatment Plant site, but not at any other location, without prejudice or claim as regards applicable patents or licenses.

1.04 SPECIAL GUARANTEE

A. Warranty: The manufacturer shall furnish a 5-year warranty protecting the Owner against equipment failure. The warranty period shall commence from the date of substantial completion of the Project.

PART 2 PRODUCTS

2.01 GENERAL

A. Contractor shall provide products required to complete the work under this section. Such products include, but are not limited to, inserts, anchor bolts, hangers and supports, specialties, and expendable materials, all as necessary to provide a complete and properly functioning system.

B. Manufacturer: Meurer Research, Inc.

2.02 OPERATIONAL DESCRIPTION

A. The feed to the basin is admitted from the flocculation basin through openings in the sedimentation basin wall. Opening size and location to be coordinated by Engineer and Manufacturer.

B. The feed enters the parallel settler plates through specially sized baffle openings in the sides of the plate packs. The flow, together with suspended matter, travels up the plates with solids settling out and sliding down the surface of the plates. The flow passes out of the space between the plates, over weirs and into the settled water collection flumes.

C. The settled water exits the flumes and flows into a common channel at the outlet end of the sedimentation basin.

2.03 DESIGN REQUIREMENTS

A. Number of Basins: A plate settler system for two basin(s) shall be provided. Refer to Contract Document Drawings for basin dimensions.

B. Flow Rates:

1. Maximum: 2.81 million gallons per day (mgd) per basin.
2. Minimum: 1.13 million gallons per day (mgd) per basin.

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C. Influent Water Quality:

1. Turbidity Range: 0.49 minimum to 11 maximum NTU, average 2.65.
2. Temperature Range: 4 degrees C to 20 degrees C.
3. pH Range: 7.9 to 8.4.
4. Alkalinity Range: 40 mg/L to 134 mg/L as CaCO3.

D. Primary Coagulant:

1. Ferric chloride (average dose, 30 mg/L).
2. Other Chemical Added: Sulfuric Acid (average dose, 30 mg/L).

E. Hydraulic Loading Rate: Maximum: 0.60 gallons per minute per square foot of projected horizontal plate area.

F. Design Loads: The structural members shall be designed to withstand hydrostatic loading, appurtenance loads, and seismic zone **[A:]** conditions. The design shall withstand all loads in submerged and nonsubmerged conditions. The frames shall be designed with a 50 psf live load and the plates shall be capable of withstanding a 50 psf live load with a 4 feet by 8 feet plywood board laid on top of the trough.

G. Plate Angle: 55 degrees from horizontal.

H. Plate Spacing: The perpendicular distance between parallel plates shall not be less than 2 inches.

2.04 EQUIPMENT DESCRIPTION

A. Plate Pack Frames:

1. Plate pack frames shall be constructed of Type 304L stainless steel. Structural members shall be suitable for long-term service with continuous immersion in the process water.
2. The plate pack frames shall be designed with anchorage baseplates at each end of the plate pack frame modules. The anchorage at one end of the frame shall be designed for fixed end conditions, and the other anchorage shall provide for movement that may result from contraction/ expansion of the plate pack frame and/or the concrete structure housing the parallel plate settlers. Frames shall be designed to span end to end without intermediate support.
3. Each frame shall be factory fabricated and shall be delivered to the Site in one piece. No field fabrication of frames will be permitted. The Contractor shall also furnish all accessories required for mounting of frames on concrete walls.

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4. The frames shall be structurally designed to span between the concrete supporting walls as indicated on Drawings and shall support all of the weight of the plates, and water and sludge loads expected. Frame deflection shall be limited to 1/360th of the span. The frames shall be designed to withstand hydrostatic uplift created when filling the sedimentation basin and shall support live loads of 50 psf.

B. Inlet Feed Baffles:

1. Inlet feed baffles and flumes shall be constructed of Type 304L stainless steel suitable for long-term service with continuous immersion in the process water and exposure to the atmosphere.
2. The inlet shall be hydraulically designed to equally distribute the influent to all of the plates. Properly sized openings in the side walls of the plates shall introduce the flocculated water near the bottom of the plates from both sides, and minimize floc destruction.

C. Parallel Plates:

1. The parallel plate assemblies shall be fabricated from Type 304L stainless steel at least 0.028 inch thick, stiffened at top and bottom with structural bend and crimp.
2. The parallel plate assemblies shall be secured in the plate pack frames in accordance with the manufacturer's standards.
3. Parallel plates shall be easily removable.

D. Outlet Weirs/Flumes:

1. Outlet weirs and flumes shall be straight-edged weirs constructed of Type 304L stainless steel.
2. V-notch weir plate shall be factory preassembled onto the top of each outlet flume side. The weirs shall be designed to allow adjustment in the field to level all weirs to the same elevation. The tops of the V-notch weirs shall be flattened to remove sharp edges that pose a safety hazard.
3. Outlet flumes shall be sized for a flow velocity of 2 fps at maximum design flow.
4. Provide a means of effluent flow balancing to ensure even flow distribution through the plates.

2.05 MATERIALS OF CONSTRUCTION

A. Fasteners:

1. Shall conform to ASTM A193 and ASTM A194, Type 304 B8MN, B8m2, or B8m3. Fasteners shall be threaded in accordance with ANSI B1.1 for screw threads, coarse-thread series. Stainless steel fasteners

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lubricant (antiseizing) shall be applied to the threads prior to making up the connections.

B. Welding:

1. All welding shall be done in accordance with the recommendations of the American Welding Society.
2. All welding shall be done by a process suitable for the materials to be welded.
3. Welds shall be free of porosity, cracks, holes, and flux.
4. All welds shall be ground smooth and shall have a uniform appearance.
5. Field welds shall be passivated prior to equipment being placed in service.

C. Passivation:

1. All fabricated stainless steel components shall be passivated using a nitric acid passivation solution.
2. Each component shall be placed in a solution of 10 percent to 15 percent nitric acid at 150 degrees F for a period of approximately 30 minutes followed by a thorough water washing.
3. If field passivation is required, a 15 percent solution of nitric acid at 65 degrees F to 80 degrees F shall be applied for a period of up to 90 minutes. The area shall be thoroughly rinsed with water after the passivating treatment.

D. Stainless Steel:

1. Swedish Steel Institute SS 2333 is equal to AISI 304L stainless steel.
2. Swedish Steel Institute SS 2343 is equal to AISI 316L stainless steel.

2.06 MISCELLANEOUS PRODUCTS

A. General:

1. Furnish incidental products, such as gaskets, supports, bolts, and lubricants, as required for proper operation of equipment installed under this section.
2. Products shall conform to applicable sections of these Specifications for the intended service.

B. Anchor Bolts:

1. Furnish anchor bolts, fasteners, washers, etc., needed for installation.
2. Verify the number and size of anchor bolts required by the manufacturer’s equipment and furnish all necessary anchor bolts.

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3. Locate anchor bolts in accordance with manufacturer's shop drawings and installation instructions.
4. Anchor bolts, fasteners, washers, etc., shall be Type 304 stainless steel or 316 stainless steel to match connecting component. Fasteners shall be threaded in accordance with ANSI B1.1 for screw threads, coarse-thread series. Stainless steel fasteners lubricant (anti-seizing) shall be applied to the threads prior to making up the connections.

PART 3 EXECUTION

3.01 PREPARATION FOR SHIPMENT

A. Insofar as is practical, the plate pack modules shall be shipped assembled, ready for installation at the Site. Parts and assemblies that are, of necessity, shipped unassembled shall be trial assembled at the factory and marked in a manner to facilitate final assembly in the field. The equipment and materials shall be packaged in a manner that will protect the equipment from damage during shipment.

B. Contractor shall have a manufacturer's representative at the Job Site during receipt of equipment and materials. This representative together with a representative of Contractor and Engineer will inspect all equipment and materials for condition upon arrival at the Job Site. Damaged or otherwise unacceptable equipment and materials will be removed from the Job Site and replaced with new equipment and materials. Accepted equipment and materials will be turned over to Contractor for storage, in accordance with the manufacturer's instructions, until installation is required.

3.02 INSTALLATION OF PARALLEL PLATE SETTLERS

A. Contractor and plate settling equipment manufacturer shall determine Site access during installation during the Bid phase.

B. A detailed description of the various items of work and precaution in handling the plate settling units shall be provided by the manufacturer to Contractor prior to delivery and installation.

C. Provide a specially fabricated sling for use with individual plate settling units before installation commences. Sling shall be the property of Owner at the end of the installation time, for plant maintenance usage.

D. Installation work shall conform to manufacturer's recommended procedures, instructions, and shop drawings.

E. Inspect, receive, unload, transport to its place of installation, store, handle, and protect equipment.

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F. Provide supervision, labor, tools, construction equipment, incidental materials, and necessary services required in install equipment.

G. Installation of the parallel plate settlers shall not begin prior to satisfactory completion of supporting structures. Support structure columns, beams, walls or slabs shall not be used to move the equipment into position.

3.03 MANUFACTURERS' SERVICES

A. A manufacturer's technical representative for the equipment specified herein shall be present at the Job Site and/or classroom designated by Owner for the minimum person-days listed for the services hereinafter, travel time excluded:

1. [1] person-day for inspection of equipment and materials upon arrival at the Job Site and inventory.
2. **[2]** person-days for inspection, certification of the installation, and instructing the installing contractor on proper installation procedures.
3. **[1]** person-day for functional testing.
4. **[1]** person-day for prestartup classroom or Job Site training.

Note: The manufacturer's representative shall be present at the Job Site for whatever duration is necessary to assure proper assembly, installation, testing, startup and certification of the equipment specified herein.

B. Startup and assistance services shall be at such times as requested by Owner. Owner will schedule such services in advance with the manufacturer. In the event of unforeseen installation difficulty or problems, the manufacturer shall provide a qualified technical representative to the Job Site within 48 hours of notification that such a situation exists.

C. Training services for Owner's personnel shall be at such times as requested by the Owner.

3.04 FUNCTIONAL TESTING

A. Functional Test: Prior to plant startup, all equipment described in this Specification shall be inspected for proper alignment and connection and satisfactory performance by means of a functional test as performed by Contractor.

3.05 SPARE PARTS

A. Furnish a minimum of two extra plates for every five plate packs.

B. Furnish ten additional fasteners of each type.

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3.06 MANUFACTURER'S CERTIFICATE

A. The following certificates shall be provided:

1. Certification of Proper Installation.
2. Certification of Materials Compliance.

END OF SECTION

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SECTION 44 44 63.01
POLYMER FEED SYSTEM, LIQUID

PART 1 GENERAL

1.01 DESCRIPTION

A. This section covers the work necessary to supply, program, fabricate, deliver, and commission polymer feed systems (System) for the following applications: Flocculation, Residuals, and Filters. A System includes but is not limited to a polymer pump, mixing chamber, local control panel (LCP), dilution water booster pumps if applicable and associated valves, piping, and instrumentation all mounted on a skid.

B. All equipment and products supplied in this section shall conform to Section 01 61 00, Common Product Requirements, and Section 40 99 90, Package Control Systems.

1.02 SUBMITTALS

A. Administrative, shop drawings, quality control, and contract closeout submittals shall conform in accordance with Section 01 33 00, Submittal Procedures.

B. Make, model, weight of equipment (System), and equipment anchoring.

C. Power requirements of the System.

D. Manufacturer’s catalog information, descriptive literature, specifications, and materials of construction.

E. Information on rotameters and mixer chamber shaft seals indicating pressure rating and service requirements specified herein.

F. Retention time and Gt (mean velocity gradient multiplied by retention time) values for polymer mixing chamber.

G. Dimensions for system components.

H. Electrical control schematic and wiring diagrams that clearly show alarms, shutdowns, and contact closures for central control system.

I. Installation requirements.

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J. Interconnection wiring diagrams showing 460-volt power distribution, 120-volt control interconnection, instrument connection, wire sizes and quantities, wire identification per control diagrams, and terminal block locations.

K. Detailed mechanical and electrical drawings of System showing equipment fabrications and interface with other items (including all equipment, piping, valves, conduit, fasteners and anchors). Include dimensions, size and locations of connections to other Work, and weights of associated equipment.

1. Record Drawings in accordance with Section 01 33 00, Submittal Procedures.

L. Operation and Maintenance Data and Manuals in accordance with Section 01 78 23, Operation and Maintenance Data.

M. Action and Informational Submittals in accordance with Section 40 99 90, Package Control Systems.

N. Manufacturer's Certificates for the following in accordance with Section 01 43 33, Manufacturers' Field Services.

O. Special shipping, storage and protection, and handling instructions.

P. List of recommended spare parts and special tools with pricing.

Q. Manufacturer's installation instructions.

R. Factory Quality Control Submittals:

1. Factory Test Plan.
2. Factory Test Report and Manufacturer's Certificate of Compliance.
3. Software Documentation.

S. Field Quality Control Submittals:

1. Component Test Plan.
2. Component Test Report and Certificate of Proper Installation.

1.03 QUALITY ASSURANCE

A. The System shall be furnished, coordinated, and tested by one supplier. The system shall be completely shop assembled**,** skid mounted, and shop tested prior to shipment.

B. All components shall be the standard product of a manufacturer regularly engaged in the production of required materials and equipment.

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C. All equipment and material shall be designed and constructed in accordance with applicable standards as indicated.

1.04 SPARE PARTS AND SPECIAL TOOLS[BM1]

A. Spare parts shall be shipped in a wooden box and be protected from damage, from moisture and dirt accumulation. Parts shall be protected as for an extended storage period. The box shall be heavily constructed with hinged cover, hasp and lock, and designed as a permanent storage enclosure for the spare parts. The spare parts shall, if possible, be enclosed within an airtight membrane. Spare parts supplied in matched sets, such as drive belts, shall be wrapped, bound, or labeled to indicate a set.

B. Furnish one year supply of lubricants including oil and greases, as recommended by the product manufacturer. The lubricants shall include summer and winter grades along with alternative references to equal products of other manufacturers including specifications such as AGMA numbers, viscosity.

1. Furnish the following:

Item	Quantity
Mechanical seal	1
Flanged bearing	1
Self-aligning bearing	1
Stator (pump)	1
Bearing, idler	1
Special tools needed for maintenance	

PART 2 PRODUCTS

2.01 GENERAL

A. The System shall be skid mounted assemblies consisting of one neat polymer metering pump, mixing chamber, and all piping, valves, and controls capable of delivering required minimum and maximum gallons per hour of polymer solution as shown in Table 1. The piping, valves, and controls to be included in each System shall include but not limited to, a pressure relief valve, pump low-flow switch, rotameter, back pressure valve, solenoid valve, pressure gauge and calibration chamber.

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B. The acceptable manufacturers (Supplier) for consideration are:

1. UGSI Chemical Feed, Inc.
2. Prominent.

2.02 SYSTEM DESIGN CRITERIA

A. The System design characteristics are summarized in Table 1.

Table 1.
Design Criteria Cutter Lateral Reach 21 Water Treatment Plant
Polymer Feed Systems

Parameter	Unit	Floc Aid & Residuals	Filter Aid
Polymer Type		Anionic	Nonionic
Equipment Name		Anionic Polymer Blending Unit	Nonionic Polymer Blending Unit
Equipment Number		PBU38060101	PBU38050101
Number of Units	#	1	1
Number of Polymer Feed Pumps per Unit	#	2 (1 Duty/1 Standby)	2 (1 Duty/1 Standby)
Min Neat Polymer Flow Rate	gph	0.005	0.001
Max Neat Polymer Flow Rate	gph	0.154	0.044
Max Solution Discharge Pressure	psi	50	10[BM2]
On-Skid Booster Pump	Y/N	N	N
Min Dilution Water Flow Rate	gph	1.094	0.208
Max Dilution Water Flow Rate	gph	30.56	8.737

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2.03 EQUIPMENT

A. General:

1. System shall consist of an integrated equipment package system which shall meter, dilute, activate, mix, and feed liquid polymer and water. System shall not rely upon a static mixer as the means of polymer activation. Polymer shall not be exposed to a rotating centrifugal pump turbine or other machinery that would cause excessive shear.
2. System shall include a progressing cavity feed pump to provide the capability of pumping emulsion type liquid polymers, with maximum apparent viscosities of up to 1,000 centipoise. At no time shall liquid polymer or polymer solution be exposed to excessive shear, so as to degrade the effectiveness of the polymer molecular chains.
3. Polymer feed system shall be furnished with an integrally mounted control panel.
4. Provide SCR drive for pump to accept 4 mA to 20 mA signal.
5. Each System shall be equipped with Type 304 stainless steel side frame and stainless steel base with nonskid feet.

B. Mixing Requirements:

1. Polymer mixing system shall be specifically designed to invert, disperse, and activate in solution emulsion polymers which may vary in specific gravity from 0.99 to 1.10 and vary in viscosity from 80 cp to 6,000 cp.
2. Polymer and water shall be mixed in a chamber designed to create sufficient mixing energy. The device shall be capable of activating and blending polymer. Polymer activation efficiency shall be consistent over the entire dilution water range. Mixing chamber shall be transparent to allow viewing of mixing intensity.
3. If the system includes a mechanical mixer, it shall be a variable speed, motor-driven impeller. Impeller shall rotate on a stainless steel shaft supported by double sealed ball bearings. The mixing impeller shall be fully controllable, capable of inducing ultra-high, nondamaging mixing energy at all flow rates, and designed to produce both axial and radial flow to optimize mixing effectiveness over the full system flow range.

C. Pump:

1. Unit shall have a neat polymer metering pump. Pump shall be progressive cavity type.
2. The metering pump shall have an output range as shown in Table 1.
3. Each metering pump shall be protected with a loss of flow sensor, rated NEMA 4 with local and remote indication of alarm on low/loss of flow.

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D. Dilution Water System:

1. Polymer feed system shall have a solenoid valve for automatic OPEN/CLOSE control of dilution water supply. Solenoid valves shall be NEMA 4X with 120V ac coil. Solenoids shall be internally controlled.
2. Dilution water system shall contain primary dilution and post dilution assemblies. Dilution system shall have a rotameter type flow indicator equipped with integral rate-adjusting valves. Total water flow rate into unit shall be adjustable as shown in Table 1.
3. Water supply pressure will be approximately 60 psig. All components in the system shall be designed for at least 100 psig working pressure.
4. Polymer feed system shall have a manufacturer's standard dilution water pressure differential type flow element and low flow switch. Flow switch and element assembly shall be installed as per manufacturer's recommendation.

2.04 CONTROL SYSTEMS

A. See Section 40 99 90, Package Control Systems, for general instrumentation and control requirements. Instrumentation, control, and electrical components provided under this section shall comply with requirements of Section 40 99 90, Package Control Systems.

B. Provide tools, documentation, hardware, software, testing equipment, and personnel to support testing and training in accordance with Section 40 99 90, Package Control Systems.

C. Package Control System shall interface with Plant SCADA via Rockwell Ethernet/IP network communications. All package control system interface control and monitoring shall be made available to Plant SCADA over networked communications.

D. Panels:

1. Provide a skid mounted control panel.
2. Material: Anodized aluminum or Type 304 stainless steel.
3. NEMA Rating: 4X.

E. Operator Controls and Indicators:

1. Provide the following panel mounted operator controls and indicators:
   a. On/Off/Remote hand switch.
   b. Pump Speed Indicator.
   c. Potentiometer (to adjust pump speed in Internal Mode).

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F. External Interfaces:

1. Analog Input(s): Pump speed adjust.
2. Discrete Input(s): System RUN command.
3. Discrete Output(s):
   a. Loss of water flow alarm.
   b. System ON status.
   c. In remote status.
4. Analog Output: Polymer pump flow rate.

G. Ancillary Instrumentation and Indicating Devices: [BM3]

1. W2 Rotameter.
2. W2 Pressure Seal and Indicator.
3. Polymer Flow Switch.
4. Polymer Pump Discharge High Pressure Switch.
5. Blending Unit Differential Pressure Switch.
6. Polymer Calibration Column.
7. Polymer Pump Discharge Pressure Seal and Indicator.
8. W2 Solenoid Valve.

H. Dilution Water Control Systems:

1. Each polymer feed system shall have an automatic actuated type dilution water control system.
2. Operator Controls and Indicators:
   a. Operator Interface Terminal (OIT) Requirements:
      1) Display On/Off/Remote.
      2) Indicate Pump Speed.
      3) Indicate Polymer Pump Feed Rate, Dilution Water Flow Rate, and Dilution Concentration.
      4) Indicate Carrier Water Flow Rate to achieve carrier water dilution set point.
      5) Ability to adjust pump speed in Manual Mode.
      6) Indicate System Running.
      7) Display all system alarms, including:
         a) Low Water Differential Pressure Alarm.
         b) Low Polymer Flow Alarm.
3. Interfaces with Package Control System equipment and Plant SCADA:
   a. Analog Input(s):
      1) Pump SPEED command.
      2) Concentration.
   b. Discrete Input(s): System RUN command.
   c. Discrete Output(s):
      1) Common ALARM.
      2) System ON status.

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3) In REMOTE status.
4) Differential pressure HIGH.
5) Pump Polymer LOW FLOW.
6) Dilution water OPEN.

d. Analog Output(s): Pump SPEED indication.

e. All package control system interface control and monitoring shall be made available to Plant SCADA over networked communications including items listed above and the following non-process status:
1) PLC operating status.
2) UPS, AC, and DC control power status.
3) Panel internal temperature indication.
4) Operating Status transferred between Plant SCADA and package system as part of water booster pump sequence of operation.
5) Operating Status transferred between Plant SCADA and package system as part of screw press operation.
6) Operating Status transferred between Plant SCADA and package system as part of RDT operation.

I. Functional Requirements:

1. When in Remote, unit runs in response to external System RUN command.
2. When in Remote, pump speed is adjusted in response to external pump speed adjust signal.
3. Monitor for Low Flow of dilution water. If falling Low Flow is sensed, put the polymer pump in standby. Once dilution water flow resumes (rising Low Flow), restart the polymer pump.
4. Activate loss of water flow alarm if Low Flow of dilution water is sensed for a preset time (initial setting, 15 seconds).
5. Monitor for Loss of Polymer Flow.
   a. System goes on standby when low/loss of polymer flow occurs, requiring a manual restart.
   b. An adjustable 0 second to 60 second time delay relay shall be provided to prevent nuisance alarms from occurring.

2.05 ELECTRICAL

A. Wiring:

1. Provide wiring between pump controller's termination enclosure, solenoid valves, pressure switches, and the pumps.
2. Provide circuit breakers and controllers for each pump.
3. One 480V ac, 15-amp power feed will be brought to the polymer unit.
4. Wiring shall be in conduit.

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5. Provide device fusing/circuit breakers as required.
6. Drives and solenoid valves shall be powered from the polymer blend unit.
7. Fuses and circuit breakers shall be housed in each respective control panel, which shall be NEMA 4X.

2.06 ACCESSORIES

A. Equipment Identification Plates: A 16-gauge stainless steel identification plate shall be securely mounted on the equipment in a readily visible location. Plate shall bear 1/4-inch die-stamped equipment identification name indicated in this Specification and/or as shown on Drawings.

B. Lifting Lugs: Equipment over 100 pounds in weight shall be provided with lifting lugs.

C. Graduated cylinder calibration kits complete with necessary control valves, connective tubing and fittings shall be furnished for each polymer feed system. Calibration columns shall be sized (capacity) as recommended by the polymer feed equipment manufacturer.

D. Pressure Relief Valve: Adjustable relief valve set at 100 psig for installation on polymer solution pipeline.

E. Ball Valves: Type V300 ball valve of suitable material for polymer application and meeting system pressure requirements.

F. Ball Check Valves: Type V630 ball check valve of suitable material for polymer application and meeting system pressure requirements.

G. Polymer blending unit shall have a check valve designed to isolate neat polymer from dilution water. The valve shall be designed with an open unobstructed path to the valve seat. Conventional check valves or check valves installed inside the mixing chamber are not acceptable. Materials shall be a Teflon body with stainless steel ball.

2.07 FACTORY TESTS

A. Shop Test: Each unit shall be shop-tested prior to shipment from the manufacturer’s factory prior to installation. WSSC may at its discretion choose to witness the shop performance test.

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PART 3 EXECUTION

3.01 EQUIPMENT INSTALLATION

A. Manufacturer of polymer feed equipment shall furnish a qualified representative who shall supervise installation of equipment, check for proper mounting, assembly, mechanical adjustment, lubrication, proper control sequencing, general functioning of equipment, and quality of workmanship. Polymer feed equipment shall be installed in strict conformance with manufacturer's recommendations.

B. Polymer equipment shall meet the requirements of applicable industrial standards or specifications as to design, construction, and performance.

C. Polymer feed system shall be installed to conform to general layout and alignment shown on Drawings.

3.02 PAINTING

A. All equipment shall be painted with manufacturer's standard painting system for corrosive service.

3.03 MANUFACTURERS' SERVICES

A. A manufacturer's representative for equipment specified herein shall be present at Job Site and/or classroom designated by WSSC for the minimum person-days listed for services hereunder, travel time excluded:

1. 2 person-days for installation assistance, inspection, certification of installation, and functional and performance testing.
2. 1 person-day for prestartup classroom or Job Site training.
3. 1 person-day for startup services.

3.04 FIELD TESTING

A. Test in accordance with general requirements in Section 01 91 14, Equipment Testing and Facility Startup.

1. Preliminary Test:
    a. Demonstrate valve operation:
        1) Check operation of OPEN/CLOSED indication lights at PLC.
        2) Open and close valves through full range and verify valve operation in manual and automatic modes. In remote mode, demonstrate that valves open and close in response to a PLC signal.

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b. Check electrical and operator controls:
    1) HAND/OFF/COMPUTER selector switch.
    2) Verify indicating lights.
    3) Stroke length adjustment
    4) Unit responds to 4 mA to 20 mA signal.
        a) Test unit for a continuous 30-minute period without malfunction under simulated operating conditions. During this operating period, the pumps shall obtain suction from the chemical storage tanks, but the Contractor shall direct the discharge to a suitable clean container for collection of the chemical. Chemical shall then be returned to the chemical storage tanks or disposed of at the direction of WSSC. During the test, record the following:
            (1) Neat polymer flow rate.
            (2) Dilution water flow rate.

END OF SECTION

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SECTION 44 46 10
SLUDGE COLLECTION EQUIPMENT

PART 1 GENERAL

_____: Sedimentation Basin 1 Sludge Collector 1.
_____: Sedimentation Basin 2 Sludge Collector 1.
_____: Backwash Waste Basin 1 Sludge Collector 1.
_____: Backwash Waste Basin 2 Sludge Collector 1.

1.01 WORK INCLUDES

A. Under this section of the Specifications, the sludge collector system shall be installed in the sedimentation basin(s) and the backwash waste pond as shown in the Contract Drawings and as described herein.

B. The sludge collector system(s) shall include tandem collector assemblies, electric drive assemblies, drive cables, sensors, rigid sludge conduit, cable pulleys, automated plug valves, main touch panel control system for fully automatic operation, and all other miscellaneous accessories and hardware as required for a complete installation. This equipment shall be provided as an integral package, manufactured by a single Supplier.

C. The sludge collector(s) shall remove by means of differential head, the settled solids from the basin floor. The solids will be discharged through the rigid sludge conduits which are connected to fixed piping to exit the basin. Flexible hoses shall not be used for sludge removal.

1.02 GENERAL

A. It is the intent of the DB Contractor that the traveling solids equipment supplier shall furnish complete an engineered system suitable for removal of coagulated solids beneath inclined plate clarifier system and settled solids from the backwash ponds.

1.03 EQUIPMENT NUMBERS

A. Sedimentation Basin No. 1, Sludge Collector (INPUT EQUIP #):

1. Sedimentation Basin No. 1, Mechanism No. 1 Local Control Panel (INPUT LCP NUMBER).
2. Sedimentation Basin No. 1, Drive Motor No. 1 (INPUT EQUIP #).

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B. Sedimentation Basin No. 2, Sludge Collector (INPUT EQUIP #):

1. Sedimentation Basin No. 2, Mechanism No. 1 Local Control Panel. (INPUT LCP NUMBER)
2. Sedimentation Basin No. 2, Drive Motor No. 1 (INPUT EQUIP #).

C. Backwash Waste Pond 1, Sludge Collector (SLC440-102-01):

1. Backwash Waste Pond 1, Mechanism No. 1 Local Control Panel. (INPUT LCP NUMBER)
2. Backwash Waste Pond 1, Drive Motor No. 1 (INPUT EQUIP #).

D. Backwash Waste Pond 2, Sludge Collector (SLC440-202-01):

1. Backwash Waste Pond 2, Mechanism No. 1 Local Control Panel. (INPUT LCP NUMBER)
2. Backwash Waste Pond 2, Drive Motor No. 1 (INPUT EQUIP #).

1.04 SUBMITTALS

A. Shop Drawings:

1. Shop Drawings shall be submitted for review and approval by DB Contractor. The Shop Drawings shall include, at a minimum, the following:
    a. Engineering drawings showing dimensional data, equipment details, materials of construction, weights, and component connections. Include a plan view drawing of the sedimentation basin showing basin features (e.g., dimensions, walls, curb, etc.) and proposed equipment.
    b. Catalog cut sheets and specifications.
    c. Data and design computations upon which the design are based, including hydraulic calculations used to determine head loss through equipment at recommended flow rate.
    d. Recommended solids removal flow rate for each unit.
    e. Drive assembly details and traveling speeds.
    f. Recommended control panel dimensional data, layouts, component descriptions, functional descriptions, ladder logic, and interface with plant PICS system.
    g. Sample power and control wiring diagrams, including terminals and numbers from similar projects.
    h. Complete motor nameplate data, as defined by NEMA, motor supplier, and including any motor modifications.
    i. Motor data sheet.
    j. Certification that submerged materials are compatible with up to 2 mg/L free chlorine in the sedimentation basin.

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B. Quality Control Submittals:

1. Operation and Maintenance Manual.
2. Certificate of Proper Installation.

1.05 STORAGE AND PROTECTION

A. Equipment and accessories shall be stored and protected in accordance with the Supplier's recommendations.

1.06 WARRANTY

A. Provide per Contract Documents.

PART 2 PRODUCTS

2.01 SYSTEM REQUIREMENTS

A. The traveling solids removal mechanism equipment shall be designed to uniformly collect sludge from the floor of the sedimentation basins. Metal coagulant sludge will be 2 percent dry solids, maximum. The equipment shall be designed to operate intermittently or continuously. All submerged components will be exposed to up to 2 mg/L free chlorine.

2.02 SUPPLIERS AND PRODUCTS

A. Meurer Industries, Inc., Golden, Colorado.

2.03 DESIGN REQUIREMENTS

A. Tank Configuration and Dimensions: As shown on Drawings.

B. Maximum Flow From Each Mechanism: Per Supplier recommendation, 200 gpm minimum.

C. Available Driving Head: 5 feet, minimum, from basin water surface to sludge wet well high level water surface.

D. Water Temperature: 0 degrees C to 30 degrees C.

2.04 EQUIPMENT DESCRIPTION

A. Each traveling solids removal mechanism shall consist of a drive mechanism, suction header pipes, rigid sludge conduits, local control panels, automated butterfly valves, and appurtenances. The traveling solids removal mechanism shall be designed, constructed, and installed in the sedimentation basins for

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the collection and removal of solids accumulated during the sedimentation process.

B. Each traveling solids collection mechanism shall be programmable to accomplish, at the operator's option, all of the following:

1. Variation of traveling speed. Traveling speeds shall be defined per Supplier recommendation.
2. One way or round trip travel for the full length of the basin.

2.05 DRIVE ASSEMBLY

A. Tandem Flow Collector System:

1. Each drive assembly shall consist of a variable speed electric AC motor which shall be coupled to a single rotating drum for manipulation of the cable attached to the tandem collector assembly. The motor drive shall be installed in the control panel. The motors shall be 1/4 hp rated for 120 volts and powered from the local control panel as specified by the Supplier. Motors shall be totally enclosed fan-cooled, squirrel cage induction type. Motors shall meet the requirements of NEMA MG 1.
2. The cable shall be firmly attached to the rotating drum to prevent slippage. Tensioning the cable between multiple pulleys to prevent slippage will not be allowed.
3. The cable shall store on the reel in a single layer, the placement of which shall be organized by the drive mechanism.
4. The complete drive mechanism shall be packaged on a single base and provided with a safety enclosure.
5. The drive enclosure shall provide a visual indication of the relative position of the collector assembly in the basin.
6. The drive assembly shall include a mechanical overload protection device that will not allow excessive loads to be transmitted to the drive cable.
7. The drive cable shall be Type 304 stainless steel with a minimum diameter of 3/16 inch.
8. The drive assembly shall be capable of enduring an indefinite stall without damage, and without the need to replace sheer pins or other replacement devices. Upon removal of the obstruction or excessive load, the drive mechanism shall automatically resume full operation.
9. The drive assembly shall have integral position sensors which determine when the collector is at the beginning and end of the basin. No external or underwater position sensors shall be required or allowed.

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2.06 TANDEM COLLECTOR ASSEMBLY

A. Tandem Flow Collector System:

1. The tandem sludge collector assembly(ies) shall be manufactured entirely of Type 316 stainless steel, with the exception of non-metallic parts such as casters, bushings, orifices, etc. which will be manufactured of plastic, non-metallic materials.
2. Each tandem collector assembly shall consist of two sludge collection pipes with helical flow orifices which are, in turn, connected to a center pipe which carries the sludge to the horizontal telescoping pipe sludge conduit.
3. The tandem collector assembly shall be designed to operate without the use of guide rails or tracks in the floor of the basin.
4. The orifices on the collectors shall be designed to allow the flow to enter tangentially into the pipe for efficient sludge removal.
5. Operation of the sludge collector shall be controlled by a butterfly valve as directed by the main control panel by an electrically actuated butterfly valve.
6. The Supplier shall determine the proper number, spacing and angle of the orifices for the most efficient removal of solids from the basin.
7. Each tandem collector assembly will be complete with polyurethane rolling casters, side casters, and all necessary mounting hardware.
8. All welds shall be continuous and brushed clean.
9. All underwater bearings shall be specifically designed for underwater use.

2.07 INSTRUMENTATION AND CONTROLS

A. General:

1. Provide all ancillary components necessary to provide an operable system in accordance with this section, whether or not the components are listed herein or shown on Drawings.
2. All elements of the instrumentation and control system shall be tested to demonstrate that the total system satisfies all the requirements of the section. Test shall demonstrate system operation through field wiring to and from interfaced equipment.
3. All electrical and controls shall meet the requirements of Section 40 99 90, Package Control Systems.

B. Sludge Collector Local Control Panel:

1. Provide sludge collector local control panel, meeting the requirements of NEMA 1.
2. The panel shall be completely assembled, prewired, and tested by the sludge collector supplier for proper control of the system.

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3. The control panel shall be provided with Modicon M340 PLC with Ethernet IP communications to the plant control system. Each panel shall also house touch screen operator interface. See Section 40 99 00, Package Control System.
4. The touch screen operator interface, as a minimum, shall be provided with the following:
    a. Overview screen displaying equipment run status, valve status, and sludge collector position.
    b. Automatic Operation: Provide sludge collector cycle initiation based on a real-time clock.
    c. Manual Operation: Provide FORWARD-REVERSE control of the sludge collector drive mechanism and the sludge collector isolation valves.
    d. Alarm summary display.
5. The control panel shall be supplied with an EMERGENCY STOP pushbutton to shut down the drive mechanism upon activation.

C. The following information, as a minimum, shall be available to the plant control system via an Ethernet communications link, as shown on the plant control system block diagram. Connection shall be made using Ethernet cable specified in Section 40 99 90, Package Control Systems.

1. Sludge collectors AUTO-MANUAL status.
2. Sludge collectors FORWARD-OFF-REVERSE status.
3. Sludge collectors isolation valve OPENED-CLOSED status.
4. Sludge collectors CYCLE START time.
5. Sludge collectors FULL CYCLE – HALF CYCLE selection.
6. Sludge collector system EMERGENCY STOP alarm.

D. Software Documentation:

1. Software documentation shall be provided prior to the functional test and an “as-built” set upon successful completion of the performance test. In addition to the requirements for documentation in Division 1, General Requirements, the Supplier shall provide the following documentation: A commented hard copy printout and electronic copy of the complete ladder diagram and display configuration. The electronic copy of the PLC program and display software shall be fully compatible with Modicon software. See Section 40 99 00, Package Control Systems for required programming software compatibility. The software shall be fully annotated and commented.

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2.08 ACCESSORIES

A. Provide end of travel limit switches and wire to a single NEMA 4X terminal box.

B. Anchors: Anchors shall be Type 316 stainless steel and designed by Supplier in accordance with Section 05 50 05, Anchorage of Equipment. Contact of anchors with concrete reinforcing steel will not be accepted.

PART 3 EXECUTION

3.01 GENERAL

A. All parts of the mechanism shall be amply proportioned for all stresses that may occur during fabrication, shipment, erection, and intermittent or continuous operation.

3.02 ASSEMBLY AND DELIVERY

A. All drive assemblies shall be shop tested prior to shipment.

B. All parts and components shall be factory-assembled in sections convenient for field handling and installation but requiring the minimum amount of work for field assembly. Any field assembly work shall be bolted. No cutting or welding should be required on either field assembly or erection.

C. All assembled parts and components ready for shipment shall be securely bundled, coiled, or crated and adequately protected from damage and corrosion during shipment and storage.

D. Equipment should be stored indoors in a dry area prior to installation.

3.03 INSTALLATION

A. Sludge collection equipment shall be installed as indicated on Drawings and in accordance with the Supplier's recommendations.

B. Provide factory certified service technician to inspect the installation, and supervise startup and initial operation of the sludge collector system.

C. Factory certified service technician to provide field support certifying that the equipment is properly installed, fully operational, and ready for use.

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3.04 FIELD QUALITY CONTROL

A. A Supplier's representative for the equipment specified herein shall be present at the jobsite and/or classroom designated by the DB Contractor for the services herein under:

1. Installation assistance, inspection, and certification of the installation.
2. Functional testing.
3. Prestartup classroom or jobsite training.

B. Functional Test: Inspect for proper alignment, quiet operation, excessive vibration, proper connection, proper control system function, and satisfactory performance by means of a functional test.

C. Startup services and training of Board's personnel shall be at such times as requested by the DB Contractor.

D. In the event of unforeseen installation difficulty or problems, the Supplier shall provide a qualified technical representative to the jobsite within 48 hours notification that such a situation exists.

3.05 SUPPLIER’S CERTIFICATE

A. The following certificates shall be provided:

1. Supplier’s Certificate of Proper Installation.

END OF SECTION

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SECTION 44 46 30
MISCELLANEOUS MECHANICAL EQUIPMENT

PART 1 GENERAL

1.01 RELATED SECTIONS

A. Related sections include the following:

1. Division 1, General Requirements.
2. Section 05 50 00, Metal Fabrications.

1.02 SUBMITTALS

A. Action Submittals:

1. Shop Drawings:
   a. Make, model, and weight of each equipment assembly.
   b. Complete catalog information, descriptive literature, specifications, and identification of materials of construction.
   c. Detailed structural and mechanical drawings showing the equipment dimensions, size, and locations of connections and weights of associated equipment.
   d. Factory finish system.
   e. Anchorage and bracing drawings and catalog information, as required by Section 01 88 15, Anchorage and Bracing, for loads in Section 01 61 00, Common Product Requirements.
   f. Motor data per Section 26 20 00, Low-Voltage AC Induction Motors.

B. Informational Submittals:

1. Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing, for loads in Section 01 61 00, Common Product Requirements.
2. Special shipping, storage and protection, and handling instructions.
3. Manufacturer’s printed installation instructions.

PART 2 PRODUCTS

2.01 FORK TRUCK

A. Provide a new 5-ton (short) LPG (Liquefied Propane Gas) powered fork truck capable of operating on concrete, asphalt and gravel roads. Fork truck must be operable indoors and outdoors, during the day and at night. Fork truck must be designed to handle chemical drums and totes and be suitable for loading or

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unloading truck and trailer beds outside of the building, and moving equipment and supplies within buildings.

B. Fork truck must include LPG tank provided by the same manufacturer as the fork truck.

C. Operating Conditions:

1. Minimum Temperature: Minus 20 degrees F.
2. Maximum Temperature: 120 degrees F.
3. Site Elevation: 6,600 feet.

D. General Requirements:

1. In accordance with applicable sections of ANSI B56 and 29 CFR 1910.
2. OSHA Classification: Class I.
3. Rated Capacity: 5 tons (10,000 pounds).
4. Tires: Pneumatic.
5. Power: LPG.
6. Operation Type: Sitting.
7. Number of Wheels, 4 Total:
   a. 2 driven.
   b. 2 steering.
8. Minimum Lift Height: 109 inches.
9. Sound Level: Less than 70 dB.
10. Emissions compliant engine.
11. One-speed powershift transmission:
    a. Electronic inching.
    b. Electronic shift control.
12. Oil-cooled wet disc brakes.
13. 2-Stage limited free-lift (LFL) mast with maximum fork height of 110 inches (2,800 mm).
14. 54 inches (1,372 mm) wide hook-type carriage with 48.0 inches (1,219 mm) tall load backrest.
15. 48 inches (1,219 mm) long forks.
16. 6 degrees forward and 12 degrees backward mast tilt.
17. 3-function hydraulic control valve.
18. Integrated dashboard display includes:
    a. LCD display.
    b. Fuel level (gasoline or diesel only).
    c. Hour meter.
    d. Coolant temperature.
    e. Clock.
    f. Messages.

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19. Service indicator lights:
    a. Alternator.
    b. Transmission oil temperature.
    c. Engine oil pressure.
    d. Brake fluid level.
    e. Fasten seatbelt.
    f. Low fuel level.
    g. Engine malfunction.
    h. System malfunction.
    i. Park brake.
    j. Coolant temp.
    k. Forward, reverse and neutral direction indicators.
20. Hydrostatic power steering.
21. Non-suspension vinyl seat.
22. Electronic horn.
23. Adjustable steer column.
24. High air intake.
25. Integral tie downs.
26. Operator restraint system.
27. Heavy duty anti-clog radiator.
28. Single pedal inch-brake.
29. Cowl-mounted hydraulic control levers.
30. Swing out LPG tank bracket.
31. Pressure sensing low LPG fuel sensor.
32. 89 inches (2,258 mm) tall overhead guard.
33. Operator's manual.
34. UL classification LP.

E. Warranty:

1. 12 months/2,000 hours manufacturer's warranty.
2. 36 months/6,000 hours manufacturer's powertrain warranty.

F. Manufacturer and Product:

1. Hyster; Model H100FT.
2. "Or-equal."

2.02 FORK MOUNTED DRUM CARRIER/ROTATOR

A. Provide a fork mounted drum carrier/rotator to handle chemical drums and totes and be suitable for loading and unloading of horizontal chemical storage and delivery racks.

B. Complies with all applicable U.S. Federal OSHA regulations.

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C. Design:

1. Drum Size: 55-gallon steel drum.
2. Rated Capacity: 1 ton (2,000 pounds).
3. Rotation Minimum: 90 degrees.

D. Manufacturer and Product:

1. Vestil Manufacturing; Model DCR-205-20.
2. “Or-equal.”

2.03 ENGINE HOIST

A. Hoist: Manually-operated hydraulic cylinder(s) to raise/lower boom with boom-mounted hook capable of movement to maintain level load (chain, wire rope or other approved method).

B. Must meet ASME PASE 2014 Safety Standards.

C. Design:

1. Capacity: 2 ton (4,000 pounds).
2. Minimum Boom Height: 0 inches.
3. Maximum Boom Height: 96.5 inches.
4. Boom Extension: 27 inches to 48 inches.
5. Portable wheeled base (6-wheel minimum).
6. Foldable for storage.
7. Construction: Heavy-duty steel.

D. Manufacturer and Product:

1. Sunex Tools; Model 5222.
2. “Or-equal.”

2.04 PORTABLE SUBMERSIBLE DEWATERING PUMP

A. Quantity: One.

B. Design Operating Point:

1. 35 gpm at 25 feet of head.
2. Max Total Dynamic Head: 35 feet.

C. Power Requirements:

1. Maximum Horsepower: 1/2 hp.
2. Voltage: 120 volts.

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3. Phase: Single.
4. Frequency: 60-Hz.

D. Materials of Construction:

1. Base Material: 304 stainless steel.
2. Impeller Material: 304 stainless steel.
3. 1-1/2-inch NPT threaded pump discharge.

E. Accessories:

1. 30-foot submersible power cable.
2. Motor thermal overload detection by means of motor temperature sensor.

F. Manufacturer and Product:

1. Goulds Water Technology; Model 1DW51C0EA.
2. “Or-equal.”

2.05 PORTABLE DAVIT CRANE

A. Crane Manufacturer and Product:

1. Thern; Model 5PT20.
2. “Or-equal.”

B. Crane Capacity: 1 ton (2,000 pounds).

C. Quantity of Crane:

1. One davit crane for use on top of the Flocculation and Sedimentation Basins.
2. Quantity of Winch, Wire Rope, and Wire Rope Accessories: One of each per crane.

D. Crane Rotation: 360 degrees.

E. Crane Boom: Telescoping type, equipped with spur gear hand-crank winch, adjustable to four different length positions and two different angle positions, minimum boom length 24 inches, maximum boom length 72 inches.

F. Wire Rope Assembly: 30 feet of 1/4-inch Type 304 stainless steel wire rope, attached with stainless steel eye hook and swaged ball fitting, accessories to include cable spool and wire rope bracket.

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G. Materials of Construction:

1. Crane: Powder coated steel.
2. Spur Gear Hand-Crank Winch: Zinc plated steel.
3. Wire Rope, Eye Hook, Swaged Ball Fitting: Type 304 stainless steel.
4. Wire Rope Cable Spool and Bracket: Type 316 stainless steel.
5. Bases: Type 304 stainless steel.

H. Surface Mount Pedestal Base:

1. Floor mounted base plate with integral Schedule 40 pipe sleeve and bottom drainage weep hole.
2. Two, floor mounted, located on top of the Flocculation and Sedimentation Basins
3. Manufacturer and Product: Thern; Model 5BP20S.

2.06 PORTABLE AIR COMPRESSOR

A. Quantity: One.

1. For maintenance of surge tank and general shop use.

B. Design Operating Point:

1. Maximum Pressure: 225 psig.
2. Cut-in Pressure: 175 psig.
3. Cut-out pressure: 225 psig.
4. Minimum scfm at 90 psig: 5 scfm.
5. ASME Certified Tank:
    a. Minimum Air Tank Volume: 15 gallons.

C. Power Requirements:

1. Maximum Horsepower: 2 hp.
2. Voltage: 120 volts.
3. Phase: Single.
4. Frequency: 60-Hz.

D. Accessories:

1. 3/8 Inch Air Hose:
    a. Length: 50-foot.
    b. Min Rated Pressure: 350 psi.
    c. Fittings: Quick connect pneumatic hose fittings capable of attaching to compressor discharge fittings.

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E. Manufacturer and Product:

1. Industrial Air; Model C151I.
2. “Or-equal.”

2.07 PORTABLE TRAILER MOUNTED HOT WATER PRESSURE WASHER

A. Provide a trailer mounted hot water pressure washer that can be truck connected and remote placed on site for cleaning, wash-down, and general maintenance of equipment.

B. Design:

1. Tank Size: 200-gallon.
2. Gasoline powered.
3. Hose filled.
4. Trailer mounted.
   Hot water heating system.

C. Manufacturers and Products:

1. Hotsy; Trail Blazer.
2. Honda; GX630 Trailer Mounted.
3. “Or-equal.”

2.08 ACCESSORIES

A. Lifting Lugs: Furnish suitably attached for equipment assemblies and components weighing over 50 pounds.

B. Equipment Identification Plates: Furnish 16-gauge Type 316 stainless steel identification plate securely mounted on each separate equipment component and control panel in a readily visible location. Plate shall bear 3/8-inch high die-stamped block type black enamel filled equipment identification tag number and letters indicated on Drawings.

C. Anchor Bolts: Minimum size of 1/2-inch diameter, Type 316 stainless steel unless otherwise indicated on Drawings; quantity and size as required by equipment manufacturer and by Subcontractor’s anchorage and bracing design per Section 01 88 15, Anchorage and Bracing. Anchor bolts shall be as specified in Section 05 50 00, Metal Fabrications.

2.09 FACTORY FINISHING

A. Submerged equipment shall be coated with the manufacturer’s standard coating system for submerged service in a municipal wastewater treatment facility. Coating systems shall at a minimum consist of appropriate surface

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preparation, primer, and a surface coat. Surface preparation and coatings shall be installed in accordance with the coating manufacturer's instructions. Acrylic or alkyd type coatings are not allowed for the surface coat.

2.10 SOURCE QUALITY CONTROL

A. Factory Inspections: Inspect equipment for required construction and intended function.

B. Factory Tests and Adjustments: Test all equipment actually furnished.

C. Factory test report of functional test.

D. Functional Test: Perform manufacturer's standard test on equipment.

PART 3 EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer's printed instructions.

B. Anchor Bolts: Accurately place using templates furnished by equipment manufacturer and as specified in Section 05 50 00, Metal Fabrications.

3.02 FIELD FINISHING

A. Touchup damaged coating on equipment as recommended by equipment manufacturer.

3.03 FIELD QUALITY CONTROL

A. Functional Tests: Conduct on all pump equipment.

1. Alignment: Test complete assemblies for proper alignment and connection, leakage, and quiet operation.

END OF SECTION

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SECTION 46 31 46
CARBON DIOXIDE FEED EQUIPMENT

PART 1 GENERAL

1.01 WORK OF THIS SECTION

A. This section includes requirements for the furnishing and installation of a complete Carbon Dioxide Pressurized Solution Feed (PSF) System. It shall be capable of producing continuous carbonic acid solution from a continuous supply of CO_2 and a side stream of carrier water, with the concentration of the solution controlled to adjust the pH of treated water prior to plant discharge. The PSF System shall automatically feed the fully dissolved CO_2 solution to the injection point as shown on Drawings and as specified herein.

B. Work Included: This section covers the Work necessary to furnish and install complete equipment and materials required for the carbon dioxide feed system. The system, as specified herein, shall be furnished by one supplier, with at least 5 years of prior experience in supplying carbon dioxide pressurized solution feed systems. The equipment furnished shall be manufactured and installed in accordance with the best practice and methods, and shall operate satisfactorily when installed as shown and as specified in the Contract Documents.

C. Unit Responsibility: The Work requires the PSF Panel, including all valves, gauges, meters, and specified components, be the end product of one responsible System Supplier.

1.02 EQUIPMENT NUMBERS

A. PSF Panel: MCS38080101.

1.03 DEFINITIONS

A. CO_2: Carbon dioxide.

B. PSF Panel: Pressurized Solution Feed Panel.

1.04 GENERAL

A. See Conditions of the Contract and Division 1, General Requirements, which contain information and requirements that apply to the work specified herein and are mandatory for this Project.

B. Like items of equipment specified herein shall be the end products of one manufacturer in order to achieve standardization in appearance, operation, maintenance, spare parts, and manufacturer's service.

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C. Operation and Maintenance manuals shall be furnished for the equipment specified herein as specified in Section 01 33 00, Submittal Procedures.

D. Piping, valves, accessories, equipment, materials, and services that are not explicitly indicated as being the responsibility of the CO_2 PSF Panel Supplier and are required for a complete and operational recarbonation system, shall be the responsibility of the Contractor.

1.05 REFERENCES

A. Reference Standards:

1. American National Standards Institute (ANSI).
2. American Welding Society (AWS).
3. American Water Works Association (AWWA).
4. Compressed Gas Association (CGA):
   a. G-6, Carbon dioxide, latest edition.
   b. C-6.1, Standard for low pressure carbon dioxide systems at consumer site, latest edition.
   c. G-6.2, Commodity Specification for carbon dioxide, latest edition.
5. Hydraulic Institute Standards (HIS).
6. Institute of Electrical and Electronic Engineers (IEEE).
7. National Electric Code, (NEC).
8. National Electrical Manufacturers Association (NEMA).
9. Occupational Safety and Health Administration (OSHA).
10. American Society of Mechanical Engineers (ASME): BPVC SEC VIII, Division 1, Rules for Construction of Pressure Vessels.

1.06 SUBMITTALS

A. Submittals during construction shall be made in accordance with Section 01 33 00, Submittal Procedures. In addition, the following specific information shall be provided:

1. Action Submittals:
   a. Shop and erection drawings showing details of construction, dimensions, and anchor bolt locations.
   b. Make and model of each equipment assembly including, but not limited to: Flow control valves, flow meters, pressure relief/control valves, isolation valves, check valves, pressure transmitters, pressure gauges, and solenoids.
   c. Descriptive literature, bulletins, and catalogue cuts for each item of equipment.
   d. The empty weight and the maximum operating weight of each major item of equipment.
   e. A complete bill of materials for all equipment.
   f. A list of the manufacturer’s recommended spare parts.

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g. Complete wiring diagrams and schematics of each control panel, controllers, and control devices.
h. Complete process instrumentation and control diagrams, wiring diagrams and schematics of all power and control systems showing the wiring requirements between all system components, motors, sensors, and control panels.
i. Calculations to verify that the equipment is designed to meet the worst-case combination of conditions based on the sizing criteria specified herein.
j. A curve showing head loss versus flow for the components of the diffuser system.
k. Anchorage and bracing drawings and cut sheets, as required by anchorage and bracing drawings.

2. Information Submittal:
   a. Anchorage and bracing calculations as required by Section 01 88 15, Anchorage and Bracing.
   b. Submit Factory and Field testing procedures and testing results.
   c. Manufacturer's Certification of Compliance that factory finish system meets requirements specified herein.
   d. Special shipping, storage and protection, and handling instructions.
   e. Operation and Maintenance Data: As specified in Section 01 78 23, Operation and Maintenance Data.
   f. Manufacturer's Certificate of Proper Installation, in accordance with Section 01 43 33, Manufacturers' Field Services.

1.07 STATEMENT OF CONFORMANCE

A. Supplier has successfully provided a minimum of 10 installations of similar scope and carrier water flow rate to CO_2 feed rate ratio during the past 5 years.

B. The manufacturer of the CO_2 PSF Panel shall inspect the completed installation and provide written certification that the system will operate as designed and specified herein.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Packing, Shipping, Handling, and Unloading: Keep all material labels or tags intact and legible.

B. Acceptance at Site:

1. Contractor shall inspect all equipment and materials against reviewed Shop Drawings at time of delivery.
2. Equipment and materials damaged or not meeting the requirements of the reviewed Shop Drawings shall be immediately returned for replacement or repair.

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C. Storage and Protection:

1. Contractor shall carefully prepare for storage and label all equipment and materials after they have been inspected.
2. Contractor shall store all equipment and materials in a dry, covered, ventilated location and protect from harm according to the manufacturer's instructions.

1.09 QUALITY CONTROL

A. Factory Acceptance Test: The CO_2 PSF Panel shall be free-standing completely enclosed panel-mounted, assembled in the factory, and operated to test the pre-programmed parameters and the functionality of the protection devices (i.e. pressures, level, flows, alarms and shutdowns and the various panel mounted sensors) before shipment to the job site. The Owner reserves the right to witness the factory acceptance test at its own cost.

PART 2 PRODUCTS

2.01 MANUFACTURERS

A. CO_2 PSF Panel:

1. TOMCO2 Systems, Loganville, GA.
2. BlueInGreen, LLC, Fayetteville, AR.
3. “Or-equal.”

2.02 GENERAL REQUIREMENTS

A. The CO_2 PSF Panel shall be furnished complete, skid mounted, factory tested, with all accessories and appurtenances as described on Drawings and Specifications herein. All parts shall have liberal strength, stability and stiffness and shall be especially adapted for the intended service. Ample room and facilities shall be provided for inspection, repairs, and adjustments.

B. Safety Devices: The completed work shall include all necessary permanent safety devices, such as machinery guards, emergency stops and similar items required by OSHA, and other federal, state, and local health and safety regulations.

C. Stainless Steel: Stainless steel components shall be 304 stainless steel, unless otherwise specified.

2.03 CARBON DIOXIDE PRESSURIZED SOLUTION FEED SKID

A. The Carbon Dioxide Pressure Solution Feed System (PSF) shall be capable of injecting and forcing Carbon Dioxide into solution at 25 degrees C, delivering

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the saturated water to a specified location, and efficiently combining the saturated water with the water to be treated, as shown on Drawings.

B. The PSF Panel shall be fully enclosed. All piping, valves, fittings, gauges, meters, and accessories shall be compatible with carbon dioxide and water.

C. The CO_2 PSF Panel supplier shall provide:

1. One (1) CO_2 PSF Panel.
2. One (1) carbonic acid solution diffuser.
    a. The CO_2 feed system supplier shall design the diffuser and submit design drawings and calculations documenting even distribution and mixing at the application point.

D. The CO_2 PSF Panel shall meet all of the following requirements:

1. Maximum feed rate (maximum day flow, maximum dose): 460 pounds of CO_2 per day.
2. Maximum carrier water flow rate (maximum day flow, maximum dose): 20 gpm.
3. Minimum feed rate (minimum day flow, minimum dose): 23 pounds of CO_2 per day.
4. Maximum Carrier Water Pressure: 60 psig.
5. CO_2 at 100 psig to 120 psig will be provided to the panel.

E. The CO_2 PSF Panel shall be capable of a minimum 10:1 turndown in CO_2 delivery rate (pounds of CO_2 per day).

F. Connections: Carbon Dioxide Inlet, Water Inlet, Water Outlet, Safety Relief Vent/Drain, Various Drains, Electrical, SCADA.

G. The PSF Panel will be located indoors.

H. The PSF Panel shall have single point of connection for 120 V, single-phase, 60 Hz power supply with a circuit breaker disconnect switch.

I. Exposed metal, except stainless steel, shall be primed painted.

J. Each PSF Panel shall include:[BM1]

1. Pressure Gauges: Four liquid filled, stainless steel pressure gauges shall be provided for mechanical measurement and display of water and gas pressure.
    a. Dial Size: 2.5 inches.
    b. Case, Tube, Socket Material: Stainless steel.
    c. Accuracy: Plus or minus 1.6 percent of full scale.
    d. Connection: 1/4 inch NPT, lower.

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2. Piping: All CO_2 piping and fittings will be 1/2 inch Type 304 stainless steel, threaded. All water piping and fittings will be 1-1/2 inches Schedule 10 Type 304 stainless steel, welded.
    a. One bronze "Y" strainer provided on the inlet side of the CO_2 feed panel to remove any debris that might pass through the CO_2 vapor line from the storage tank and piping system.
3. One second stage pressure reducing valve, will be supplied. The regulator will reduce the CO_2 pressure from the storage tank to the desired operating pressure. The regulator will have a malleable iron body, aluminum spring case and lower case, nitrile and aluminum valve disc and holder, nylon fabric coated with nitrile diaphragm, stainless steel valve stem and valve stem guide. The outlet pressure of the regulator will be easily adjusted through the use of an adjustment screw.
4. Two pressure gauges, 2-1/2 inch dial, 0 psi to 200 psi range, complete with isolation valves, shall be provided for indication of the CO_2 pressure upstream and downstream of the second stage pressure regulator.
5. One glass tube-type indicating CO_2 flow meter shall be provided. The frame will be stainless steel with stainless steel end fittings. A glass tube with a stainless steel float will be utilized. Accuracy of the meter will be 2 percent of full scale. The flow meter shall be sized to correspond with the design rate of carbon dioxide per hour.
6. One pH indicating PID controller (AIT-700) will be provided. The controller will be complete with proportional band, integral, transit time, reset functions, set point, output indication, remote pH transmission, manual/automatic selection and hi/low pH alarms. The controller will receive an electronic signal from the pH probe. The controller will transmit a proportional 4 mA to 20 mA dc signal to the electro-pneumatic transducer. The pH controller shall be a Series 56 controller specially designed for TOMCO2 by Rosemount.
7. One pH electrode assembly (AE-700) will be provided. The electrode assembly will include a pH glass electrode, a reference electrode, a thermo-compensator and a preamplifier, all enclosed in a corrosion-proof PEEK body. The electrode assembly will be located 60 seconds to 90 seconds downstream of the CO_2 application point for measurement of the pH, and then transmits the pH measurement signal to the pH controller. The electrode assembly will be complete with 10 meters of cable and insertion hardware for mounting in the treated water pipeline or sampling line.
8. One gas actuated (ATO) CO_2 flow control valve assembly will be provided. The pneumatically operated, spring opposed diaphragm actuator is controlled via an electronic signal from an electro-pneumatic I/P transducer. The transducer converts a DC current input signal to a directly proportional pneumatic output. The transducer is designed to accept a proportional 4 mA to 20 mA dc signal from the pH controller. The valve actuator will be supplied complete with a CO_2 gas regulator

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for utilizing the CO_2 gas at the panel as the pneumatic source. The valve body shall be Type 316 stainless steel. Valve and actuator shall be Badger.

9. One manually operated by-pass CO_2 flow control valve will be supplied. The valve will be stainless steel construction and designed for positive control of CO_2 flow.
10. Four CO_2 isolation ball valves will be supplied; one for the panel and two for the control valve by-pass, and one for the solenoid by-pass. The valve bodies will be of Type 316 stainless steel construction with stainless steel trim. The valves will be designed specifically for CO_2 service.
11. Two pressure gauges, 2-1/2 inch dial, 0 psig to 160 psig range, complete with isolation valves, shall be provided for indication of the water pressure upstream and downstream of the mixers.
12. Two in-line mixers designed to continuously mix carbon dioxide with the water will be supplied. The CO_2 vapor will be injected upstream of the mixer though a stainless steel diffuser. The mixers shall be constructed of PVC.
13. One Hand/Auto/Off switch and power light will be provided on the control panel door. The switch will provide 120V ac power to the electronics in the panel.
14. One stainless steel ball check valve will be provided in the CO_2 injection line.
15. One carrier water drain valve will be supplied. The valve body will be of stainless steel construction with stainless steel trim.
16. One piston actuated CO_2 solenoid valve, with manual bypass, will be provided for shutting off the CO_2 flow with a signal from the plant control system. The solenoid valve shall have a stainless steel body, CO_2 actuator, CO_2 pressure regulator, speed control and a 120-volt solenoid on the CO_2 pneumatic source.
17. One carrier water low pressure switch and alarm light shall be provided. A low water pressure signal (dry contact) shall be provided to the plant control system.
18. Three pressure relief valves shall be provided for protection of the PSF Panel components. The valves shall have a brass body and stainless steel spring. Safety relief valves shall be set to relieve at 150 psig, 100 psig, and 50 psig.
19. All necessary panel valves, safeties, gauges, pipe, pipe fittings, etc. will be included as part of the PSF Carbonic Acid feed system panel. Programmable Logic Controller: Allen Bradley CompactLogix L33ER[BM2].
20. Control Panel:
    a. The skid-mounted CO_2 PSF Panel shall have a control panel enclosure installed on the door which operates all components, in the panel.

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b. The control panel enclosure shall be stainless steel rated NEMA 4X and be constructed following UL standards.
c. At a minimum, the front of the control panel shall include: Controller Display, System Hand/Off/Auto switch, Power Present Light, Low pH Alarm Light, High pH Alarm Light, low carrier water pressure alarm light.
d. The control panel shall provide manual and automatic control for the unit.

2.04 CONTROLS

A. General:

1. Provide control devices, instruments and panels in accordance with general control requirements specified in Section 40 99 90, Package Control Systems.
2. The minimum functional requirements of the control system are specified herein. Provide additional instrumentation and controls as to provide and safe and operable system.
3. The CO_2 PSF Panel shall be provided with sufficient panel-mounted instrumentation and controls such that all system parameters shown below may be monitored and controlled locally by the operator or remotely via the Owner's SCADA system.

B. The CO_2 PSF Panel shall have Local (Hand) and Remote (Auto) Operating modes

1. When in (Auto), the Panel shall operate to feed carbon dioxide gas at a CO_2 flow rate to achieve a pH setpoint as set in the pH controller.
2. The Panel shall have two different Local (Hand) operating modes.
   a. Manual Bypass Control: The CO_2 flowrate shall be adjusted by the operator at the panel by isolating the automatic control valve and using the manual by-pass needle valve to set a CO_2 flow rate as indicated on the CO_2 rotameter.
   b. Automatic Manual Control: The CO_2 flowrate shall be set adjusted by the operator at the panel by using the touch screen display on the pH controller vary the automatic control valve position to set a CO_2 flow rate as indicated on the CO_2 rotameter.

C. The following signals, controlled by the Owner's SCADA system, shall be exchanged, between the SCADA and CO_2 PSF Panel.

1. Signals from the CO_2 PSF Panel to SCADA shall include:
   a. Status (Running, Stopped, Shutdown).
   b. Low pH Alarm.
   c. High pH Alarm.
   d. Remote/Local mode.

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e. Carrier Water Pressure alarm.
f. Process pH.

2. Signals from SCADA to the CO_2 PSF Skids: Start/Stop Command.

D. Control of the system shall be accomplished by a dedicated pH controller located on the PSF panel.

E. All Alarms and warnings shall be active in both Automatic and Manual modes of operation.

F. Alarms shall be identified for each protection monitored parameter.

G. Time delay shall be provided to allow the carrier water to come up to pressure prior to injection of the CO_2 while starting the equipment.

2.05 CARBONIC ACID SOLUTION DIFFUSER:

A. The CO_2 PSF Panel Supplier shall furnish the diffuser assembly capable of providing a minimum transfer efficiency of 95 percent at the flow rates and water depth shown on the drawings. The assembly shall be designed to distribute carbonic acid solution over the entire cross sectional area of the flow stream such that all process water is adjusted to the target pH prior to reaching the downstream pH measurement point.

1. The diffuser assembly shall consist of 304 stainless steel construction, Schedule 40 and a flanged connection to the supply piping.
2. The diffuser shall achieve adequate dispersion with a minimum differential pressure of 45 psi across the orifices.

2.06 SPARE PARTS

A. Provide all special tools required for repair or rebuilding.

B. Furnish 1 year supply of lubricants including oil and greases, as recommended by the product manufacturer in original sealed containers correctly identified as to brand and grade with reference to the particular piece(s) of equipment for which it is intended. The lubricants shall include summer and winter grades along with alternative references to equal products of other manufacturers, including specifications such as AGMA numbers and viscosity.

PART 3 EXECUTION

3.01 ASSEMBLY AND PREPARATION FOR SHIPMENT

A. Each unit shall be completely factory assembled, aligned, and securely packaged for shipment. Accessory equipment which cannot be shipped

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assembled to the unit, such as spare parts, shall be separately packaged, clearly marked as to the contents, and shipped on the same shipment as the unit.

3.02 EQUIPMENT INSTALLATION

A. The equipment specified herein shall be installed in conformance with the manufacturer's recommendations.

B. The Contractor shall retain ultimate responsibility under this Contract for equipment coordination, installation, operation and guarantee, and the Contractor shall furnish and install all labor, equipment, materials, appurtenances, specialty items, and services not provided by the supplier but required for a complete and operable system.

C. All piping shall be supported so as to preclude the possibility of exerting undue forces and moments on the joints. Suitable flexible joints shall be furnished to isolate the units from the piping system.

D. Manufacturer's Certificate(s): Provide manufacturer's certificate(s) in accordance with Section 01 43 33, Manufacturer’s Field Services of Division 1, General Requirements.

3.03 FIELD PERFORMANCE TEST

A. Functional Test:

1. The CO_2 PSF Panel shall be operated by the System Supplier, in the presence of the Owner, to demonstrate specified CO_2 delivery requirements are achieved with installed equipment.
   a. Alarm set points.
   b. Operational modes as listed in Article Controls.
2. PSF Panel supplier will perform any repairs or modifications required to achieve the specified performance at no cost to the Owner.

B. Performance Test:[BM3]

1. The CO_2 PSF Panel shall be operated by the System Supplier, in the presence of the Owner, to demonstrate compliance with the specified performance, including: Panel shall operate in Remote (Auto) pH control mode with pH variation of no more than plus or minus 0.2 pH units from set point.

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C. Manufacturer's Services:[BM4]

1. A manufacturer’s representative for the equipment specified herein shall be present at the site for the minimum person-day’ listed for the serviced hereinafter, travel time excluded.
   a. 1 person-day, for instructing the Contractor on proper installation techniques, inspection of installation.
   b. 2 person-days, for functional and performance testing, training of Owner’s personnel, and completion of Manufacturer’s Certification of Proper Installation.
   c. A person-day constitutes 8 hours spent at the site and does not include travel to and from the site.
2. Provide Qualifications of Manufacturer’s Representative.
3. Startup services and training of Owner’s personnel shall be at such times as requested by Contractor and approved by Owner.
4. See Section 01 43 33, Manufacturers' Field Services of Division 1, General Requirements.

END OF SECTION

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