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
PIPELINE AND TANK 3

60 Percent Submittal

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Denver, CO

December 29, 2017

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Project No. 682853

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SURVEYING

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:

1. Surveying requirements related to establishment of elevations, lines, and levels and certification of elevations and locations of the Work conforming with the Contract Documents.

B. Related Sections:

1. Section 01 00 00 - Basic Requirements.

2. Section 31 23 17 - Trenching: Execution requirements for trenching.

3. Section 33 11 13 - Public Water Transmission Systems.

1.2 UNIT PRICE - MEASUREMENT AND PAYMENT

A. Construction Staking and As-Built Surveying:

1. Incidental for items of work requiring surveying.

1.3 SUBMITTALS

A. Submit the following in accordance with Section 01 00 00 – Submittals and Section 01 00 00 – Project Record Drawings.

B. Surveying plan:

1. Describe work layout and survey methods.

2. Include surveying schedule.

C. Lead Surveyor Résumé:

1. Surveyor responsible for supervising and directing survey work for approval.

D. Accuracy check results:

1. Accuracy check of Bureau of Reclamation - established primary control Reports shall be signed & sealed by a New Mexico Registered Professional Land Surveyor.

E. Completed and reduced survey notes:

1. Copy of completed and reduced survey notes for a survey or portion of survey.

F. Original field survey books.

G. Quantity survey notes and computations:

1. Copies required for progress payment. Include itemized statement for work covered by notes and computations. Reports shall be signed & sealed by a New Mexico Registered Professional Land Surveyor.

H. Workday's survey notes:

1. Copies when requested by Engineer.

1.4 PRIMARY CONTROL

A. The Bureau of Reclamation has established primary control to be used for establishing work lines and grades.

B. Primary control consists of bench marks and horizontal control points in work vicinity.

C. Contractor shall check and verify primary control and resolve discrepancies with Engineer before beginning work.

D. Contractor shall preserve and maintain primary control points until otherwise authorized.

1.5 QUALIFICATIONS

A. Provide experienced construction surveyors under the supervision and direction of a New Mexico Registered Professional Surveyor for all construction staking and as-built surveys.

PART 2 PRODUCTS

2.1 SURVEYING MATERIALS AND EQUIPMENT

A. Provide materials and equipment required for surveying work, including, but not limited to instruments, stakes, spikes, steel pins, templates, platforms, and tools.

B. Except as required to be incorporated in work or left in place, surveying materials and equipment will remain property of Contractor.

PART 3 EXECUTION

3.1 CONSTRUCTION STAKING

A. Establish lines and grades for work layout from Bureau of Reclamation - established primary control points.

B. Establish measurements required for work execution to specified tolerances.

C. Provide stakes, markers, and other survey controls necessary to control, check, and guide construction.

3.2 SURVEY REQUIREMENTS

A. Contractor is advised that a typical 60’ wide permanent right-of-way easement is established along the proposed pipeline alignment, 30’ to each side of the centerline. An additional 20’ is provided on each side of this permanent easement to provide a temporary use area, resulting in a total of 100’ wide corridor in which the Contractor must stage and limit all construction activities.

1. Contractor is advised that at certain locations the right-of-way and/or temporary use area is truncated on one side or the other to avoid encroaching on adjacent properties. These areas are indicated on the Drawings. Contractor shall not encroach beyond the established work space in these areas.

B. ROW Staking:

1. Surveyor shall stake the rights-of-way and temporary use area boundaries as well as pipe centerline, with offsets as needed, a minimum of every 100 feet and at all horizontal points of inflection.

2. Where the temporary use area is truncated, the surveyor shall clearly mark the truncated ends of the temporary use area with multiple stakes and/or other form of barricade acceptable to the Engineer to protect against inadvertent encroachment outside the designated work area by construction personnel or others.

C. Pipe Profile Staking:

1. Vertical tangents: Each 100 feet.

2. Vertical curves: At Beginning of Vertical Curve, point of inflection, and End of Vertical Curve, as indicated on Drawings.

D. Structures: Complete stake out of structures and checkouts before and during construction.

E. Roads: Blue tops each 50 feet on tangent and each 25 feet on curves.

F. Cross-sections: Original, final and intermediate as required, for structure sites and other locations as necessary for quantity surveys. Survey borrow areas before and after removal of materials, but before final shaping.

G. As-builts:

1. Pipe: The centerline of pipe shall be surveyed after laying of pipe in trench, but prior to placing backfill over the top of the pipe or other features to be surveyed.

a. If the pipe is found to be outside of the line and grade specifications established in Section 33 11 13 - Public Water Transmission Systems, Contractor will be required to correct line and grade and re-survey.

b. If the Contractor elects to place embedment prior to surveying, this is done at the Contractor's own risk. The Contactor shall be responsible for the cost of re-excavation, re-embedment, re-compaction and re-testing of any embedment material that must be removed in order to correct pipe line and grade.

c. If the Engineer suspects that the pipe has floated or otherwise moved after centerline surveying, the affected portion shall be resurveyed as directed by the Engineer. All conditions noted above for pipe found to be outside line and grade specifications shall apply equally to re-surveyed pipe.

2. As-built surveying intervals:

a. Pipe:

1) Vertical tangents: Each 100 feet.

2) Vertical curves: At beginning of Vertical Curve, point of inflection, and End of Vertical Curve, as indicated on Drawings. In addition, each 100 ft along curve, if the aforementioned points are more than 200 ft apart.

3) All high points and low points.

b. Valves and pipe fittings:

1) Centerline of pipe at all risers for air valves.

2) Centerline of all in-line valves.

3) Centerline of all fittings, such as tees, wyes and ells.

c. Structures:

1) Finished floors at all corners of buildings.

2) Center of rims for all manholes and vaults.

3) Tank base, surveyed at four locations at 90 degrees to each other.

4) BMPs installed as part of the SWPPP. Refer to SWPPP for requirements.

3. As-built survey submittals:

a. Shall be stamped and signed by a New Mexico Registered Professional Land Surveyor.

b. Shall tie to established control provided by Engineer.

c. Shall utilize coordinate systems and map datum as directed by Engineer.

d. Shall clearly state date of completion and equipment used.

3.3 ACCURACY

A. Degree of Accuracy of Surveying:

1. Horizontal and vertical alignment of pipeline tangents and curves: Within 0.1 ft.

2. Structure Points: Set within 0.01 foot, except where installation or operation considerations require tighter tolerances.

3. Blue Tops: Set within 0.01 foot.

4. Cross-Section Points: Locate within 0.10 foot, horizontally and vertically.

5. Vertical Elevation Surveys: For surveys not utilizing GPS, close within 0.05 foot times the square root of the circuit length in miles.

3.4 FIELD RECORDS

A. Notes shall be collected on an electronic data collection device approved by the Engineer.

1. Submit electronic files of notes in approved format.

2. Submit paper copies of notes upon request from the Engineer.

END OF SECTION

SECTION 03 10 00

CONCRETE FORMS AND ACCESSORIES

PART 1 GENERAL

1.1 SUMMARY

A. The Contractor shall furnish all materials for concrete formwork, bracing, shoring and supports and shall design and construct all forms, bracing, shoring and falsework, all in accordance with the requirements of the Contract Documents.

B. Section Includes:

1. Formwork for cast-in place concrete.
2. Shoring, bracing, and anchorage.
3. Form accessories.
4. Form stripping.

C. Related Sections:

1. Section 03 20 00 - Concrete Reinforcement.
2. Section 03 30 00 - Cast-in-Place Concrete.

1.2 REFERENCES

A. International Building Code (IBC), as referenced herein, shall be the most recent New Mexico Construction Industries Division (CID) adopted edition

B. American Concrete Institute:

1. ACI 117 - Standard Specifications for Tolerances for Concrete Construction and Materials.
2. ACI 301 - Specifications for Structural Concrete.
3. ACI 318 - Building Code Requirements for Structural Concrete.
4. ACI 347 - Guide to Formwork for Concrete.

C. Government Standards:

1. PS 1-74 U.S. Product Standard for Concrete Forms, Class I.

D. American Forest and Paper Association:

1. AF&PA - National Design Specifications for Wood Construction.

E. The Engineered Wood Association:

1. APA/EWA PS 1 - Voluntary Product Standard for Construction and Industrial Plywood.

F. ASTM International:

1. ASTM D1751 - Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types).

2. ASTM E96 - Standard Test Methods for Water Vapor Transmission of Materials.

1.3 SUBMITTALS

A. Section 01 00 00 - Submittal Procedures: Requirements for submittals.

B. Product Data:

1. List of form materials and locations of use.

2. Form release agent with EPA Certification.

1.4 QUALITY ASSURANCE

A. Tolerances: The variation from established lines and grades shall not exceed 1/4-inch in ten (10) feet and there shall be no offsets or visible waviness in the finished surface. All other tolerances shall be within the "Suggested Tolerances" specified in Section 3.3 and 3.4 of ACI 347.

PART 2 PRODUCTS

2.1 FORM MATERIALS

A. Except as otherwise expressly accepted by the Engineer, all lumber brought on the job site for use as forms, shoring or bracing shall be new material. All forms shall be smooth surface forms and shall be of the following materials:

1. Walls: Steel or plywood panel

2. All Other Work: Steel panels, plywood or tongue and groove lumber

2.2 FORM TIES

A. Form ties with Integral water stops shall be provided with a plastic cone or other suitable means for forming a conical hole to ensure that the form tie may be broken off back of the face of the concrete.

1. The maximum diameter of removable cones for rod ties, or of other removable form-tie fasteners having a circular cross-section, shall not exceed 1-inch and all such fasteners shall be such as to leave holes of regular shape for reaming.

2. Form ties for water-retaining structures shall have integral water stops. Removable taper ties may be used when approved by the Engineer. A preformed neoprene or polyurethane tapered plug sized to seat at the center of the wall shall be inserted in the hole left by the removal of the taper tie.

2.3 FORM AND FALSEWORK MATERIALS

A. Materials for concrete forms, formwork and falsework shall conform to the following requirements:

1. Lumber shall be Douglas Fir or Southern Pine, construction grade or better, in conformance with U.S. Product Standard PS10.

2. Plywood for concrete formwork shall be new, waterproof, synthetic resin bonded, exterior type Douglas Fir or Southern Pine plywood manufactured especially for concrete formwork and shall conform to the requirements for PS 1 for Concrete Forms, Class I, and shall be edge sealed.

3. Form materials shall be metal, wood, plywood or other approved material that will not adversely affect the concrete and will facilitate placement of concrete to the shape, form, line and grade shown. Metal forms shall be an approved type that will accomplish such results. Wood forms for surfaces to be painted shall be Medium Density Overlaid plywood, MDO Ext. Grade.

B. Unless otherwise shown, exterior corners in concrete members shall be provided with 3/4-inch chamfers. Re-entrant corners in concrete members shall not have fillets unless otherwise shown.

PART 3 EXECUTION

3.1 EXAMINATION

A. Section 01 00 00 - Administrative Requirements: Coordination and project conditions.

B. Verify lines, levels, and centers before proceeding with formwork. Verify dimensions agree with Drawings.

C. When formwork is placed after reinforcement resulting in insufficient concrete cover over reinforcement before proceeding, request instructions from Engineer.

3.2 GENERAL

A. Forms to confine the concrete and shape it to the required lines shall be used wherever necessary. The Contractor shall assume full responsibility for the adequate design of all forms. Forms which are unsafe or inadequate in any respect shall promptly be removed from the Work and replaced at the Contractor's expense. A sufficient number of forms of each kind shall be provided to permit the required rate of progress to be maintained. The design and inspection of concrete forms, falsework and shoring shall comply with applicable Local, State and Federal regulations. Plumb and string lines shall be installed before concrete placement and shall be maintained during placement. Such lines shall be used by Contractor's personnel and by the Engineer and shall be in sufficient number and properly installed. During concrete placement the Contractor shall continually monitor plumb and string line form positions and immediately correct deficiencies.

B. Concrete forms shall conform to the shape, lines and dimensions of structural components as called for on the Drawings and shall be free from surface defects and sufficiently tight to prevent leakage.

3.3 FORM DESIGN

A. All forms shall be true in every respect to the required shape and size, shall conform to the established alignment and grade and shall be of sufficient strength and rigidity to maintain their position and shape under the loads and operations incident to placing and vibrating the concrete.

B. Suitable and effective means shall be provided on all forms for holding adjacent edges and end of panels and sections tightly together and in accurate alignment so as to prevent the formation of ridges, fins, offsets or similar surface defects in the finished concrete.

C. Plywood, 5/8-inch and greater in thickness, may be fastened directly to studding if the studs are spaced close enough to prevent visible deflection marks in the concrete. The form joints shall be tight so as to prevent the loss of water, cement and fines during the placing and vibrating of the concrete. The bottom of the wall forms that rest on concrete footings or slabs shall be provided with a gasket to prevent loss of fines and paste during placement and vibration of concrete. Adequate cleanout holes shall be provided at the bottom of each lift of forms.

3.4 INSTALLATION

A. Formwork - General:

1. Construct forms to correct shape and dimensions, mortar-tight, braced, and of sufficient strength to maintain shape and position under imposed loads from construction operations.

2. All vertical surfaces of concrete members shall be formed.

3. Carefully verify horizontal and vertical positions of forms. Correct misaligned or misplaced forms before placing concrete.

4. Complete wedging and bracing before placing concrete.

B. Forms for Smooth Finish Concrete:

1. Use steel, plywood or lined board forms.

2. Use clean and smooth plywood and form liners, uniform in size, and free from surface and edge damage capable of affecting resulting concrete finish.

3. Install form lining with close-fitting square joints between separate sheets without springing into place.

4. Use full size sheets of form lines and plywood wherever possible.

5. Tape joints to prevent protrusions in concrete.

6. Use care in forming and stripping wood forms to protect corners and edges.

7. Level and continue horizontal joints.

8. Keep wood forms wet until stripped.

C. Forms for Surfaces to Receive Membrane Waterproofing: Use plywood or steel forms. After erection of forms, tape form joints to prevent protrusions in concrete.

D. Framing, Studding and Bracing:

1. Size framing, bracing, centering, and supporting members with sufficient strength to maintain shape and position under imposed loads from construction operations.

2. Distribute bracing loads over base area on which bracing is erected.

3. When placed on ground, protect against undermining, settlement or accidental impact.

E. Erect formwork, shoring, and bracing to achieve design requirements, in accordance with requirements of ACI 301.

F. Arrange and assemble formwork to permit dismantling and stripping. Do not damage concrete during stripping. Permit removal of remaining principal shores.

G. Obtain Engineer's approval before framing openings in structural members not indicated on Drawings.

H. Install fillet and chamfer strips on external corners of beams, joists, and/or columns, as called for on the Drawings.

I. Install void forms in accordance with manufacturer's recommendations.

3.5 APPLICATION - FORM RELEASE AGENT

A. Apply form release agent on formwork in accordance with manufacturer's recommendations.

B. Apply prior to placement of reinforcing steel, anchoring devices, and embedded items.

C. Do not apply form release agent where concrete surfaces are indicated to receive special finishes or applied coverings that are affected by agent. Soak inside surfaces of untreated forms with clean water. Keep surfaces coated prior to placement of concrete.

D. Reuse and Coating of Forms: Thoroughly clean forms and reapply form coating before each reuse. For exposed work, do not reuse forms with damaged faces or edges. Apply form coating to forms in accordance with manufacturer's specifications. Do not coat forms for concrete indicated to receive "scored finish". Apply form coatings before placing reinforcing steel.

3.6 INSTALLATION - INSERTS, EMBEDDED PARTS, AND OPENINGS

A. Install formed openings for items to be embedded in or passing through concrete work.

B. Locate and set in place items required to be cast directly into concrete.

C. Install accessories straight, level, and plumb. Ensure items are not disturbed during concrete placement.

D. Install water stops continuous without displacing reinforcement.

E. Provide temporary ports or openings in formwork where required to facilitate cleaning and inspection. Locate openings at bottom of forms to allow flushing water to drain.

F. Close temporary openings with tight fitting panels, flush with inside face of forms, and neatly fitted so joints will not be apparent in exposed concrete surfaces.

G. Form Ties:

1. Use sufficient strength and sufficient quantity to prevent spreading of forms.

2. Leave inner rods in concrete when forms are stripped.

3. Space form ties equidistant, symmetrical and aligned vertically and horizontally unless otherwise shown on Drawings.

4. Holes left by the removal of form tie cones shall be reamed with suitable toothed reamers so as to leave the surface of the holes clean and rough before being filled with mortar as specified for "Finish of Concrete Surfaces" in Section 03 30 00 - Cast-In-Place Concrete.

5. Wire ties for holding forms will not be permitted. No form-tying device or part thereof, other than metal, shall be left embedded in the concrete. Ties shall not be removed in such manner as to leave a hole extending through the interior of the concrete members. The use of snap-ties which cause spalling of the concrete form stripping or tie removal will not be permitted.

6. If steel panel forms are used, rubber grommets shall be provided where the ties pass through the form in order to prevent loss of cement paste. Where metal rods extending through the concrete are used to support or to strengthen forms, the rods shall remain embedded and shall terminate not less than 1-inch back from the formed face or faces of the concrete.

H. Removable Ties:

1. Where taper ties are approved for use, the larger end of the taper tie shall be on the wet side of walls in water retaining structures. After the taper tie is removed, the hole shall be thoroughly cleaned and roughened for bond.

2. A precast neoprene or polyurethane taped plug shall be located at the wall centerline. The hole shall be completely filled with non-shrink grout for water bearing and below-grade walls. The hole shall be completely filled with non-shrink grout for above-grade walls that are dry on both sides.

3. Exposed faces of walls shall have the outer 2-inches of the exposed face filled with a cement grout which shall match the color and texture of the surrounding wall surface.

I. Arrangement: Arrange formwork to allow proper erection sequence and to permit form removal without damage to concrete.

J. Construction Joints:

1. Concrete construction joints will not be permitted at locations other than those shown or specified, except as may be acceptable to the Engineer.

2. Install surfaced pouring strip where construction joints intersect exposed surfaces to provide straight line at joints.

3. Just prior to subsequent concrete placement, remove strip and tighten forms to conceal shrinkage.

4. Show no overlapping of construction joints. Construct joints to present same appearance as butted plywood joints.

5. Arrange joints in continuous line straight, true and sharp.

K. Embedded Items:

1. Make provisions for pipes, sleeves, anchors, inserts, reglets, anchor slots, nailers, water stops, and other features.
2. Do not embed wood or uncoated aluminum in concrete.
3. Obtain installation and setting information for embedded items furnished under other Specification sections.
4. Securely anchor embedded items in correct location and alignment prior to placing concrete.
5. Verify conduits and pipes, including those made of coated aluminum, meet requirements of ACI 318 for size and location limitations.

L. Openings for Items Passing Through Concrete:

1. Frame openings in concrete where indicated on Drawings. Establish exact locations, sizes, and other conditions required for openings and attachment of work specified under other sections.
2. Coordinate work to avoid cutting and patching of concrete after placement.
3. Perform cutting and repairing of concrete required as result of failure to provide required openings.

M. Screeds:

1. Set screeds and establish levels for tops of concrete slabs and levels for finish on slabs.
2. Slope slabs to drain where required or as shown on Drawings.
3. Before depositing concrete, remove debris from space to be occupied by concrete and thoroughly wet forms. Remove freestanding water.

N. Screed Supports:

1. For concrete over waterproof membranes and vapor retarder membranes, use cradle, pad or base type screed supports which will not puncture membrane.
2. Staking through membrane is not permitted.

O. Cleanouts and Access Panels:

1. Provide removable cleanout sections or access panels at bottoms of forms to permit inspection and effective cleaning of loose dirt, debris and waste material.
2. Clean forms and surfaces against which concrete is to be placed. Remove chips, saw dust and other debris. Thoroughly blow out forms with compressed air just before concrete is placed.

3.7 MAINTENANCE OF FORMS

A. Forms shall be maintained at all times in good condition, particularly as to cleanliness, strength, rigidity, tightness and smoothness of surface. After forms have been removed from a concrete placement they shall be immediately and thoroughly cleaned and repaired, and surface treated before reuse.

B. The form surfaces shall be treated with a non-staining mineral oil or other lubricant acceptable to the Engineer. Any excess lubricant shall be satisfactorily removed before placing the concrete. Oil shall be kept off the surfaces of steel reinforcement and other metal items to be embedded in concrete.

3.8 FORM REMOVAL

A. Do not remove forms or bracing until concrete has gained sufficient strength to carry its own weight and imposed loads and removal has been approved by Engineer.

B. No forms shall be disturbed or removed under an individual panel or unit before the concrete in the adjacent panel or unit has attained seventy-five percent (75%) of the specified 28-day strength and has been in place for a minimum of seven (7) days. Forms for all vertical walls and columns shall remain in place at least forty-eight (48) hours after the concrete has been placed, except for periods of cold weather when forms shall remain in place at least seventy-two (72) hours after concrete has been placed.

C. Loosen forms carefully. Do not wedge pry bars, hammers, or tools against finish concrete surfaces scheduled for exposure to view.

D. Store removed forms in manner that surfaces to be in contact with fresh concrete will not be damaged. Discard damaged forms.

E. Leave forms in place for minimum number of days as specified in ACI 347.

3.9 REUSE OF FORMS

A. Forms may be reused only if in good condition and only if acceptable to the Engineer. Light sanding between uses will be required wherever necessary to obtain uniform surface texture on all exposed concrete surfaces. Exposed concrete surfaces are defined as surfaces that are permanently exposed to view.

3.10 FALSEWORK

A. The Contractor shall be responsible for the design, engineering, construction, maintenance and safety of all falsework, including staging, walkways, forms, ladders and similar appurtenances, which shall equal or exceed the applicable requirements of the provisions of the OSHA Safety and Health Standards for Construction, and the requirements specified herein.

B. All falsework shall be designed and constructed to provide the necessary rigidity and to support the required dead load plus a minimum of 40 psf live load. Falsework for the support of a superstructure shall be designed to support the loads that would be imposed if the entire superstructure were placed at one time. Falsework shall be placed upon a solid footing, safe against undermining and protected from softening. When falsework is supported on any portion of the structure that is already constructed, the load imposed by the falsework shall be spread, distributed and braced in such a way as to avoid any possibility of damage to the structure. Falsework supported off finished floor slabs shall be set in such a way to protect the finish floor surface from being scarred, chipped or gouged.

3.11 FIELD QUALITY CONTROL

A. Section 01 00 00 - Execution Requirements: Field inspecting, testing, adjusting, and balancing.

B. Inspect erected formwork, shoring, and bracing to ensure that work is in accordance with formwork design, and that supports, fastenings, wedges, ties, and items are secure.

C. Notify Engineer after placement of reinforcing steel in forms, but prior to placing concrete.

D. Schedule concrete placement to permit formwork inspection before placing concrete.

END OF SECTION

SECTION 03 20 00

CONCRETE REINFORCEMENT

PART 1 GENERAL

1.1 SUMMARY

A. The Contractor shall furnish, fabricate and place all concrete and masonry reinforcement steel, including all the tie wires, clips, supports, chairs, spacers and other accessories, all as shown and specified in the Contract Documents. All requirements included on the Drawings shall apply and shall take precedent over any indications in the present Section of the technical specifications in the case of contradictions.

B. Related Sections:

1. Section 03 10 00 - Concrete Forms and Accessories.

2. Section 03 30 00 - Cast-in-Place Concrete.

1.2 REFERENCES

A. Codes:

1. The International Building Code, as referenced herein, shall be the most recent New Mexico Construction Industries Division (CID) adopted edition of International Building Code (IBC).

B. American Concrete Institute:

1. ACI 301 - Specifications for Structural Concrete.

2. ACI 315 - Details and Detailing of Concrete Reinforcement.

3. ACI 318 - Building Code Requirements for Structural Concrete.

4. ACI SP-66 - ACI Detailing Manual.

C. ASTM International:

1. ASTM A82 - Standard Specification for Steel Wire, Plain, for Concrete Reinforcement.

2. ASTM A184/A184M - Standard Specification for Fabricated Deformed Steel Bar Mats for Concrete Reinforcement.

3. ASTM A185 - Specification for Welded Steel Wire Fabric (Latest Edition) for Concrete Reinforcement.

4. ASTM A496 - Standard Specification for Steel Wire, Deformed, for Concrete Reinforcement.

5. ASTM A497 - Standard Specification for Steel Welded Wire Fabric, Deformed, for Concrete Reinforcement.

6. ASTM A615/A615M - Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.

7. ASTM A934/A934M - Standard Specification for Epoxy-Coated Prefabricated Steel Reinforcing Bars.

8. ASTM A996/A996M - Standard Specification for Rail-Steel and Axle-Steel Deformed Bars for Concrete Reinforcement.

9. ASTM D3963/D3963M - Standard Specification for Fabrication and Jobsite Handling of Epoxy-Coated Reinforcing Steel Bars.

D. American Welding Society:

1. AWS D1.4 - Structural Welding Code - Reinforcing Steel.

E. Concrete Reinforcing Steel Institute:

1. CRSI - Manual of Standard Practice (Latest Edition).

2. CRSI - Placing Reinforcing Bars (Latest Edition).

F. Wire Reinforcement Institute:

1. Manual of Standard Practice for Welded Wire Fabric.

1.3 SUBMITTALS

A. The Contractor shall furnish to the Engineer reinforcing steel placing drawings. These drawings shall show the number, grade, size, length, mark, location and bending diagrams for all reinforcing steel and related products, together with lists of bent and straight bars in accordance with the ACI Detailing Manual (latest edition) of the American Concrete Institute and the requirements specified herein and shown on the Contract Drawings. The Engineer may or may not review the placement drawings. Any review of the placement drawings by the Engineer will be limited to general compliance with the Contract Documents and will not be returned to the Contractor. Reinforcing steel placement will be checked in the field using the design drawings. Any discrepancies, errors or omissions from the requirements of the Contract Documents shall be corrected prior to placement of concrete and at the sole expense of the Contractor.

1.4 QUALITY ASSURANCE

A. When required by any applicable permits, such as CID permits, Contractor shall have reinforcement inspected by the agency with jurisdiction prior to placement of concrete.

B. If requested by the Engineer, the Contractor shall provide a certified copy of the mill test report showing physical and chemical analysis for each heat of reinforcement steel delivered.

PART 2 PRODUCTS

2.1 REINFORCEMENT STEEL

A. Reinforcement steel for all cast-in-place reinforced concrete construction shall conform to the following requirements:

1. Bar reinforcement shall conform to the requirements of ASTM A615 for Grade 60 Billet Steel Reinforcement.

2. Welded wire fabric reinforcement shall conform to the requirements of ASTM A185 and the details shown. Welded wire fabric with longitudinal wire equal to or less than 4.0 size wire shall be either furnished in flat sheets or in rolls with a core diameter or not less than 10-inches. Welded wire fabric with longitudinal wires larger than 4.0 size shall be furnished in flat sheets only.

B. Accessories:

1. The Contractor shall furnish and install all accessories including necessary chairs or bolsters, concrete blocks (dobies), tie wires, supports, spacers and other devices to position reinforcement during concrete placement.

2. Wire bar supports shall be made of plain cold-drawn steel wire with pre-molded, gray-colored, plastic tips to the legs of the support. The plastic shall have a thickness of 1/8-inch or greater at points of contact with formwork and extend upward on the wire a minimum of 1/2-inch. Wire sizes and geometric dimensions shall be made in accordance with Table II of the latest edition of CRSI Manual of Standard Practice.

3. Concrete blocks (dobies), used to support and position reinforcement steel, shall have the same or higher compressive strength as specified for the concrete in which it is located. Where the concrete blocks are used on concrete surfaces exposed to view, the color and texture of the concrete blocks shall match that required for the finished surface. Wire ties shall be embedded in concrete block bar supports.

4. The wire tie shall be 16-gauge or heavier, black annealed.

2.2 MECHANICAL COUPLERS

A. Mechanical couplers shall be provided where shown and where approved by the Engineer. The couplers shall develop a tensile strength that exceeds one hundred fifty percent (150%) of the yield strength of the reinforcement bars being spliced at each splice.

PART 3 EXECUTION

3.1 GENERAL

A. All reinforcement steel, welded wire fabric, couplers and other appurtenances shall be fabricated and placed in accordance with the requirements of the Contract Documents, including referenced specifications, codes and standards.

3.2 FABRICATION

A. Reinforcement steel shall be accurately fabricated to the dimensions and shape shown in the Contract Documents. Fabricating details shall be prepared in accordance with ACI 315 and ACI 318, except as modified by the Drawings. Bends shall conform to bend dimensions defined as standard in accordance with details in the ACI Detailing Manual and/or CRSI Manual of Standard Practice, unless otherwise shown. Bars shall be bent cold and shall not be bent or straightened in a manner that will injure the material. All hooks shall conform to bend dimensions defined as ACI Standard Hooks.

B. The Contractor shall fabricate reinforcement bars within the tolerances shown in the ACI Detailing Manual and/or CRSI Manual of Standard Practice.

C. Reinforcing bars delivered to the field shall be tagged with durable material and marked in a legible manner with waterproof markings. Tags shall show the grade, number of pieces, size and mark or length of bars.

3.3 PLACING

A. Reinforcing steel shall be accurately positioned as shown on the Contract Documents and placed per the minimum clearance requirements given on the Drawings, and shall be adequately supported and wired together to prevent displacement. All reinforcement steel shall be supported or spaced off the forms by concrete or metal supports which are rigid enough to prevent any displacement or the reinforcement steel. Where concrete is to be placed on the ground, supporting concrete blocks (or dobies) shall be used, in sufficient numbers to support the bars without settlement. Concrete blocks shall not be used as spacers between mats. All concrete blocks used to space reinforcement steel off vertical formed surfaces shall be tied to the steel with wire ties which are embedded in the blocks. For reinforcement including welded wire fabric over formwork, the Contractor shall furnish concrete or metal supports with plastic covered legs for bar supports.

B. Tie wires shall be bent away from the forms in order to provide the specified concrete coverage.

C. Bars additional to those shown which may be found necessary or desirable by the Contractor for the purpose of securing reinforcement in position shall be provided by the Contractor at its own expense.

D. Placing Tolerances: Unless otherwise specified, reinforcement placing tolerances shall be within the limits specified in Section 7.5 of ACI 318, except where in conflict with the requirements of Building Code.

E. Bars may need to be moved to avoid interference with other reinforcement steel, conduits or embedded items. If bars are moved more than one bar diameter, or enough to exceed the above tolerances, the resulting arrangement of bars shall be as acceptable to the Engineer. Additional bars may be necessary to prevent cracking or provide additional reinforcement in this case and shall be provided by the Contractor at its own expense.

F. Welded wire fabric placed over the ground shall be supported on wired concrete blocks (dobies) spaced not more than three (3) feet on centers in any direction. The construction practice of placing welded wire fabric on the ground and hooking into place in the freshly placed concrete shall not be used.

3.4 SPACING OF BARS

A. The clear distance between parallel bars (except in columns and between multiple layers of bars in beams) shall be not less than the nominal diameter of the bars nor less than 1-1/3 times the maximum size of the coarse aggregate, nor less than 1-inch.

3.5 SPLICING

A. General: Reinforcement bar splices shall only be used at locations shown, unless otherwise acceptable to the Engineer.

B. Splices of Reinforcement: The length of lap for reinforcement bars, unless otherwise shown shall be in accordance with ACI 318, Section 12.15.1 for a class C splice.

C. Laps of welded wire fabric shall be in accordance with ACI 318. Adjoining sheets shall be securely tied together with No. 14 tie wire, one tie for each two (2) running feet. Wires shall be staggered and tied in such a manner that they cannot slip.

D. Bending or Straightening: Reinforcement shall not be straightened or rebent in a manner which will injure the material. Bars with kinks or bends not shown shall not be used. All bars shall be bent cold, unless otherwise permitted by the Engineer. No bars partially embedded in concrete shall be field-bent, except as specifically permitted by the Engineer.

3.6 CLEANING AND PROTECTION

A. Reinforcing steel delivered to the jobsite shall be suitably stored off the ground and protected from oils, mud, concrete splatter and all conditions conducive to corrosion until embedded in concrete.

B. The surfaces of all reinforcement steel and other metalwork to be in contact with concrete shall be thoroughly cleaned of all dirt, grease, loose scale and rust, grout, mortar and other foreign substances immediately before the concrete is placed. Where there is delay in depositing concrete, reinforcement shall be reinspected and, if necessary, recleaned.

END OF SECTION

SECTION 03 29 00

JOINTS IN CONCRETE

PART 1 GENERAL

1.1 SUMMARY

A. The Contractor shall construct all construction joints, expansion joints and control joints in concrete at the locations shown and formed in accordance with the details shown in the drawings.

B. Related Sections:

1. Section 03 10 00 - Concrete Forms and Accessories.
2. Section 03 20 00 - Concrete Reinforcement.
3. Section 03 30 00 - Cast-in-Place Concrete.

1.2 REFERENCES

A. Federal Specifications:

1.	TSS-S-00227E(3)	Sealing Compound, elastomeric type, multi-component (for Caulking, Sealing, Glazing Buildings and Other Structures)
2.	CRD-C 572	U.S. Army Corp of Engineers Specifications for PVC Waterstop

B. Commercial Standards:

1.	ASTM C 920-86	Specification for Elastomeric Joint Sealants
2.	ASTM D 624-81	Test Method for Rubber Property - Tear Resistance
3.	ASTM D 1752-84	Specification for Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction

1.3 QUALITY ASSURANCE

A. Construction Joint Sealant: The Contractor shall prepare adhesion and cohesion test specimens as specified herein from each shipment of material received at the jobsite. Sealant shall be stored at room temperature and shall not be stored longer than seventy-five percent (75%) of the manufacturer's stated shelf life.

B. The sealant material shall show no signs of adhesive or cohesive failure when tested in accordance with the following procedure:

1. Sealant specimen shall be prepared between two concrete blocks (1-inch by 2-inch by 3-inch). Spacing between the blocks shall be 1/2-inch. Coated spacers (2-inch by 1-1/2 inch by 1/2-inch) shall be used to ensure sealant cross-sections of 1/2-inch by 2-inches with a width of 1/2-inch.

2. Sealant shall be cast and cured according to manufacturer's recommendations except that curing period shall not exceed twenty-four (24) hours.

3. Following curing period, the gap between blocks shall be widened to 1-inch. Spacers shall be used to maintain this gap for twenty-four (24) hours prior to inspection for failure.

PART 2 EXECUTION

2.1 JOINT CONSTRUCTION

A. Joint Location: Construction joints, expansion joints and control joints shall be provided where shown. When not shown, construction joints shall be provided at 25-foot maximum spacing for all concrete construction, unless noted otherwise. The location of all joints shall be submitted for acceptance by the Engineer.

B. Special care shall be used in preparing concrete surfaces at joints where bonding between two (2) sections of concrete is required. Unless otherwise shown, such bonding will be required at all horizontal joints in walls and wall to slab joints. Surfaces shall be prepared by sandblasting and washing for removal of latence or any objectionable material. Joints shall be kept clean until the concrete is placed. Vertical joints shall be clean and free of concrete fins, rock pockets or any objectionable material.

C. Sealant grooves shall be formed as shown on the drawings and shall be protected from damage until final application of the sealant. Care shall be taken to prevent chipping of the sealant grove during removal of forms.

END OF SECTION

SECTION 03 30 00

CAST-IN-PLACE CONCRETE

PART 1 GENERAL

1.1 SUMMARY

A. The Contractor shall furnish all materials for concrete in accordance with the provisions of this Section and shall form, mix, place, cure, repair, finish, and do all other work as required to produce finished concrete, in accordance with the requirements of the Contract Documents. All requirements included on the Drawings shall apply and shall take precedent over any indications in the present Section of the technical specifications in the case of contradictions.

B. The following types of concrete shall be covered in this Section:

1. Sitework Concrete: Concrete to be used for curbs, gutters, catch basins, sidewalks, pavements, thrust blocks, fence and guard post embedment, and other concrete ties unless otherwise shown.

2. Structural Concrete: Concrete to be used where noted in the Contract Documents.

3. Lean Concrete: Concrete to be used for pipe trench cut-off walls and cradles, where the preceding items are detailed on the Drawings as un-reinforced.

C. The term "hydraulic structure" used in these specifications shall refer to environmental engineering concrete structures for the containment, treatment, or transmission of water, wastewater, or other fluids.

D. Related Sections:

1. Section 03 10 00 - Concrete Forms and Accessories.

2. Section 03 20 00 - Concrete Reinforcement.

3. Section 03 29 00 - Joints in Concrete.

4. Section 03 60 00 - Grout.

5. Section 31 23 23 - Backfill.

6. Section 32 31 13 - Chain Link Fences and Gates.

7. Section 33 11 13 - Public Water Transmission Systems.

1.2 REFERENCES

A. American Concrete Institute:

1. ACI 117 - Standard Tolerances for Concrete Construction and Materials.

2. ACI 214 - Recommended Practice for Evaluation of Strength Test Results of Concrete.

3. ACI 301 - Specifications for Structural Concrete.

4. ACI 305 - Specification for Hot Weather Concreting

5. ACI 306 - Cold Weather Concreting.

6. ACI 308.1 - Standard Specification for Curing Concrete.
7. ACI 309 - Consolidation of Concrete.
8. ACI 318 - Building Code Requirements for Structural Concrete.

B. ASTM International:

1. ASTM C31/C31M - Standard Practice for Making and Curing Concrete Test Specimens in the Field.
2. ASTM C33 - Standard Specification for Concrete Aggregates.
3. ASTM C39 - Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.
4. ASTM C40 - Test Method for Organic Impurities in Fine Aggregates for Concrete.
5. ASTM C94/C94M - Standard Specification for Ready-Mixed Concrete.
6. ASTM C136 - Method for Sieve Analysis of Fine and Coarse Aggregates.
7. ASTM C143/C143M - Standard Test Method for Slump of Hydraulic Cement Concrete.
8. ASTM C150 - Standard Specification for Portland Cement.
9. ASTM C156 - Test Methods for Water Retention by Concrete Curing Materials.
10. ASTM C157 - Test Method for Length Change of Hardened Hydraulic Cement Mortar and Concrete.
11. ASTM C172 - Standard Practice for Sampling Freshly Mixed Concrete.
12. ASTM C192 - Method of Making and Curing Concrete Test Specimens in the Laboratory.
13. ASTM C227 - Test for Potential Alkali Reactivity of Cement- Aggregate Combinations.
14. ASTM C260 - Standard Specification for Air-Entraining Admixtures for Concrete.
15. ASTM C309 - Specifications for Liquid Membrane-Forming Compounds for Curing Concrete.
16. ASTM C441 - Test for Effectiveness of Mineral Admixtures in Preventing Excessive Expansion of Concrete Due to Alkali-Aggregate Reaction.
17. ASTM C494/C494M - Standard Specification for Chemical Admixtures for Concrete.
18. ASTM C1077 - Practice for Laboratories Testing Concrete and Concrete Aggregates for Use in Construction & Criteria for Laboratory Evaluation.
19. ASTM D2419 - Test Method for Sand Equivalent Value of Soils and Fine Aggregate.
20. ASTM C618 - Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete.

1.3 SUBMITTALS

A. General**:** Submittals shall be submitted to the Engineer for review in accordance with Section 01 00 00, Contractor Submittals. Submittals shall include, but not be limited to the following:

1. Mix Designs**:** Prior to beginning the Work and within 14 days of the Notice To Proceed, the Contractor shall submit to the Engineer, for review, the proposed ready-mix supplier and their Laboratory-Certified concrete mix design for each class and type of concrete specified for the Work. Submitted mix designs shall have been performance-tested and certified by an independent laboratory approved by the Owner. Physical properties, including slump, air content, density and compressive strength shall be included with the submitted tests. All costs related to providing mix design shall be borne by the Contractor. Mix designs shall show the following in accordance with ACI 301:

a. Proportions for all materials proposed.

b. Mill tests for cement.

c. Admixture certification, chloride ion content must be included.

d. Aggregate gradation and certification.

2. Delivery Tickets: Where ready-mix concrete is used, the Contractor shall furnish delivery tickets at the time of delivery of each load of concrete. Each ticket shall show the state certified equipment used for measuring and the total quantities, by weight of cement, sand, each class of aggregate, admixtures, and the amounts of water in the aggregate added at the batching plant, and the amount allowed to be added at the site for the specific design mix. In addition, each ticket shall state the approved mix design number, total yield in cubic yards, and the time of day, to the nearest minute, corresponding to the times when the batch was dispatched, when it left the plant, when it arrived at the site, when unloading began, and when unloading was finished.

3. Materials and methods for curing:

a. List of curing methods to be used on each type and class of concrete.

b. Curing compound.

c. Curing blankets and mats.

d. Evaporation retardant.

1.4 QUALITY ASSURANCE

A. When required by any applicable permits, such as CID permits, Contractor shall have reinforcement inspected by the agency with jurisdiction prior to placement of concrete.

B. General:

1. Tests on concrete will be field performed in accordance with all requirements of applicable ASTM standards for such tests, including but not limited to obtaining samples, temperature, slump, air entrainment, making and curing specimens, breaking concrete cylinders, and other as may be applicable.

2. The cost of all laboratory tests on cement, aggregates, and concrete, for the development of the mix design, will be borne by the Contractor. The laboratory must meet or exceed the requirements of ASTM C1077.

3. Concrete for testing shall be supplied by the Contractor as part of the project cost, and the Contractor shall provide assistance in obtaining samples, and disposal and cleanup of excess material.

4. Test cylinders will be prepared one (1) test each day of placement for each mixture for the first 50 or less cubic yards and one (1) test for each additional 100 cubic yards of concrete.

C. Compression Tests:

1. Compression test specimens will be taken during construction from the first placement of each class of concrete specified herein and at intervals thereafter as indicated above to ensure continued compliance with these specifications. Each set of test specimens will be a minimum of 5 cylinders.

2. Compression test specimens for concrete shall be made in accordance with ASTM C31. Specimens shall be 6-inch diameter by 12-inch high cylinders.

3. Compression tests shall be performed in accordance with ASTM C39. One test cylinder will be tested at 7 days and 2 at 28 days. The remaining cylinders will be held to verify test results, if needed.

4. Compression testing will be paid for by the Owner.

D. Evaluation and Acceptance of Concrete:

1. Evaluation and acceptance of the compressive strength of concrete shall be according to the requirements of ACI 318, and as specified herein.

2. All concrete that fails to meet the ACI requirements and these specifications, is subject to removal and replacement at the cost of the Contractor.

3. Concrete delivered to the site that does not meet the requirements as herein specified may be rejected.

1.5 CONSTRUCTION TOLERANCES

A. The Contractor shall set and maintain concrete forms and perform finishing operations so as to ensure that the completed work is within the tolerances specified herein. Surface defects and irregularities are defined as finishes and are to be distinguished from tolerances. Tolerance is the specified permissible variation from lines, grades, or dimensions shown. Where tolerances are not stated in the specifications, permissible deviations will be in accordance with ACI 117.

B. The following construction tolerances are hereby established and apply to finished walls and slabs unless otherwise shown:

Item	Tolerance
Variation of the constructed linear outline from the established position in plan.	In 10 feet: 1/4-inch In 20 feet or more: 1/2-inch
Variation from the level or from the grades shown.	In 10 feet: 1/4-inch In 20 feet or more: 1/2-inch
Variation from the plumb.	In 10 feet: 1/4-inch In 20 feet or more: 1/2-inch
Variation in the thickness of slabs and walls.	Minus 1/4-inch; Plus 1/2-inch
Variation in the locations and sizes of slabs and wall openings.	Plus or minus 1/4-inch

PART 2 PRODUCTS

2.1 CONCRETE MATERIALS

A. Unless sulfate tests dictate otherwise, all cement shall be standard brand Portland Cement conforming to ASTM C150 for Type II, low alkali. Portland Cement shall contain not more than 0.60 percent total alkalies. The term "alkalies" is defined as the sum sodium oxide (Na_2O), potassium oxide (K2O), calculated as sodium oxide (.658 K2O). Only one (1) brand of cement shall be used for exposed concrete in any individual structure. The cement shall be suitably protected from exposure to moisture until used. Certified mill test reports for each shipment of cement to be used shall be submitted to the Engineer. Mill test reports shall include the alkali content.

B. Water shall be potable, clean and free from objectionable quantities of silty organic matter, alkali, salts and other impurities. The water shall be considered potable, for the purpose of this Section only, if it meets the requirements of the local governmental agencies. Agricultural water with high total dissolved solids (over 1000 mg/l TDS) shall not be used.

C. All concrete aggregates shall be obtained from pits acceptable to the Engineer, shall be non-reactive, sound, uniformly graded and free of deleterious material in excess of allowable limits specified. Combined aggregates shall be well graded from coarse to fine sizes, and be uniformly graded between screen sizes to produce a concrete that has optimum workability and consolidation characteristics. Lightweight sand for fine aggregate will not be permitted. Aggregates shall conform to ASTM C33.

1. Coarse Aggregate: Coarse aggregate shall consist of gravel, crushed gravel or crushed stone made up of clean, hard, durable particles free from calcareous coatings, organic matter or other foreign substances. Thin or elongated pieces having a length greater than four (4) times the average thickness shall not exceed fifteen percent (15%) by weight. Deleterious substances shall not be present in excess of the following percentages by weight, and in no case, shall the total of all deleterious substances exceed one and one-half percent (1.5%):

Soft Fragments	1.5%
Shale	1.5%
Coal and Lignite	0.25%
Clay Lumps	0.25%
Materials Finer than No. 200 Sieve	0.50%*

*Except that when material finer than No. 200 sieve consists of crusher dust, the maximum amount maybe 1%.

Except as otherwise specified or approved in writing by the Engineer, coarse aggregate shall be graded as specified in ASTM C33, size No. 57.

2. Fine Aggregate: Fine aggregate for concrete or mortar shall consist of clean, natural sand or a combination of natural and manufactured sands that are hard and durable. Deleterious substances shall not be present in excess of the following percentages by weight of contaminating substances. In no case shall the total exceed three percent (3%):

Removed by Decantation (Dirt, Silt, Etc.)	3%
Shale	1%
Clay Lumps	1%

Fine aggregate shall not contain strong alkali nor organic matter which gives a color darker than a standard color when tested in accordance with ASTM C40. Fine aggregate shall have a fineness modulus not less than 2.50 nor greater than 3.00. Except as otherwise specified, fine aggregate shall be graded from coarse to fine in accordance with the requirements of ASTM C33.

D. If non-reactive aggregates are unavailable, and either the coarse or fine aggregates are found to be alkali-silica reactive, the Contractor shall submit a proposed design mix that effectively mitigates the alkali-silica reactivity, per ASTM C441. The admixture will be considered effective if the mean mortar bar expansion at 14 days is less than or equal to 0.10%.

E. Admixtures of any type, except as otherwise specified, shall not be used unless written authorization has been obtained from the Engineer. The use of calcium chloride will not be permitted.

1. All concrete shall contain five percent (5%), plus or minus one percent (1%) entrained air of evenly dispersed air bubbles at the time of placement. The air-entraining agent shall contain no chloride and conform to ASTM C260, or U.S. Army Corps of Engineers Specifications CRD-C13. The air-entraining agent shall be added to the batch in a portion of the mixing water. The solution shall be batched by means of a mechanical batcher capable of accurate measurement. The Engineer, or Owner and his duly authorized representatives reserve the right, at any time, to sample and test the air-entraining agent or the air content of concrete received on the job by the Contractor. Air entrainment in the concrete shall be tested by ASTM C138, ASTM C231 or ASTM C173. If any sample tested does not have the specified air content, a second test shall be performed. If

the second test does not meet the specified air content, the concrete represented by the test shall be removed from the job.

2. A "super plasticizer" water reducing agent may be used at the Contractors option, subject to approval by the Engineer, for concrete in hydraulic structures. The amount of cement in the mix shall not be reduced. The slump may be increased to a maximum of 8-inches. Quantities of admixtures and procedures shall be in accordance with the manufacturers published recommendations. The super plasticizer shall conform to ASTM C494, Type F or G. The admixture shall be a second-generation type, free of chlorides and alkalies, composed of a synthesized sulfonated complex polymer that shall be added to the concrete mixer at the batch plant.

3. Fly ash/pozzolan shall conform to ASTM C618, including the requirements of Table 1A, therein, and the following supplementary requirements:

a. Class F Fly Ash

Loss on ignition, maximum	1%
SO3 content, maximum	3%
Moisture content, maximum	1%
R = (CaO - 5%)/(Fe_2O_3), maximum	1.5

2.2 CONCRETE CURING MATERIALS

A. Materials for curing concrete shall conform to the following requirements:

1. Concrete curing compound shall be Protex LR-151 as manufactured by Protex Industries, Denver, CO; Hunt Process Clear ARB as manufactured by Hunt Process Co., Santa Fe Springs, CA; Select Cure CRB as manufactured by Select Products Co., Upland, CA; or equal. The curing compound shall contain a fugitive dye so that areas of application will be readily distinguishable. All admixtures, including superplasticizers, shall be included in submittals in the mix proportions.

2. Polyethylene sheet for use as concrete curing blanket shall be white and shall have a normal thickness of 10 mils.

3. Burlap, cotton mats or other covering material for use as concrete curing blanket must be overlapped adequately to ensure 100% coverage at all times, and must not be allowed to become dry at any point during the curing period

4. The loss of moisture, when determined in accordance with the requirements of ASTM C156, shall not exceed 0.055 grams per square centimeter of surface.

2.3 CONCRETE DESIGN REQUIREMENTS

A. General: The concrete mixes shall be designed to produce a concrete of such consistency and composition so as to obtain maximum density and minimum shrinkage. Mix designs with more than forty-one percent (41%) of sand of the total weight of fine and coarse aggregate shall not be used.

B. Water-Cement Ratio and Compressive Strength: The minimum compressive strength and cement content of concrete shall not be less than that specified in the following Table, or as otherwise indicated on the Drawings:

Type of Work	Min. 28-Day Compressive Strength (psi)	Max. Size Aggregate (in.)	Max. Water/ Cement Ratio (by wt.)
Slabs on grade, footings, floor slabs, and all other concrete items not specified elsewhere.	4,000	1	0.5
Exterior Flat Work	4,000	1	0.45
Sitework Concrete	3,000	1	0.45
Lean Concrete	2,500	1	0.59

C. Adjustments to Mix Design: The mixes used shall be changed whenever such change is necessary or desirable to secure the required strength, density, workability and surface finish and the Contractor shall be entitled to no additional compensation because of such changes.

D. At the Contractors option, fly ash/pollozan may be used as a partial cement replacement in concrete as follows:

1. Fly ash shall replace not more than twenty five percent (25%) by weight of the Portland Cement in the design mix. The design mix shall contain a minimum of six (6) sacks of cement per cubic yard before the replacement is made.
2. Fly ash for all structures shall be Class F fly ash.
3. If the coarse or fine aggregates are proven to be potentially alkali-silica reactive per ASTM C227, the mineral admixture Class F fly ash shall be proportioned by weight of cement to provide a fly ash to portland cement ratio not less than 1:4, not less than 20 percent of the total cementitious material. The Contractor shall provide the Engineer with chemical and physical analysis of the fly ash, and detailed design mix to meet the requirements of ASTM C441.

2.4 CONSISTENCY

A. The consistency of the concrete in successive batches shall be determined by slump tests in accordance with ASTM C 143. The slumps shall be as follows:

Part of Work	Slump (inches)
Footings and Slabs	3-inches + 1/2-inches, - 1 inch.
Other Work	3-inches ± 1-inch.
With High Range Water Reducer Added 8-inches maximum.	

2.5 TRIAL BATCH AND LABORATORY TESTS

A. Before placing any concrete, the Contractor shall submit the certified trial batch results of each class of concrete having a 28-day strength of 3,500 psi or higher, based on the preliminary concrete mixes submitted by the Contractor. All concrete shall conform to the requirements of this Section, whether the aggregate proportions are from the Contractors preliminary mix design, or whether the proportions have been adjusted during the trial batch process. The trial batch shall be prepared using the aggregates, cement and admixture proposed for the project. The trial batch materials shall be of a quantity such that the testing laboratory can obtain three (3) drying shrinkage, and six (6) compression test specimens from each batch. The costs for the trial batch tests shall be borne by the Contractor.

B. The determination of compressive strength will be made by testing 6-inch diameter by 12-inch high cylinders; made, cured and tested in accordance with ASTM C192 and ASTM C39. Three (3) compression test cylinders will be tested at 7-days and three (3) at 28-days. The average compressive strength for the three (3) cylinders tested at 28-days for any given trial batch shall not be less than one hundred twenty-five percent (125%) of the specified compressive strength.

C. A standard sieve analysis of the combined aggregate for each trial batch shall be performed according to the requirements for ASTM C136. Values shall be given for percent passing each sieve.

2.6 SHRINKAGE LIMITATION

A. Drying shrinkage specimens shall be 4-inch by 4-inch by 11-inch prisms with an effective gage length of 10-inches, fabricated, cured, dried and measured in accordance with ASTM C157 modified as follows: Specimens shall be removed from molds at an age of 23+ hours after trial batching, shall be placed immediately in water at 70 degrees F. ±3 degrees F. for at least thirty (30) minutes, and shall be measured within thirty (30) minutes thereafter to determine original length and then submerged in saturated lime water at 73 degrees F. ±3 degrees F. Measurement to determine expansion expressed as a percentage of original length shall be made at age 7-days. This length at age 7-days shall be the base length for drying shrinkage calculations ("0" days drying age). Specimens then shall be stored immediately in a humidity control room maintained at 73 degrees F. ±3 degrees F. and fifty percent (50%) ±4 percent relative humidity for the remainder of the test. Measurements to determine shrinkage expressed as percentage of base length shall be made and reported separately for 7, 14, 21 and 28-days of drying after 7-days of moist curing.

B. The drying shrinkage deformation of each specimen shall be computed as the difference between the base length (at "0" days drying age) and the length after drying at each test age. The average drying shrinkage deformation of the specimens shall be computed to the nearest 0.0001-inch at each test age. If the drying shrinkage of any specimen departs from the average of that test age by more than 0.0004-inch, the results obtained from that specimen shall be disregarded. Results of the shrinkage test shall be reported to the nearest 0.001 percent of shrinkage. Compression test specimens shall be taken in each case from the same concrete used for preparing during shrinkage specimens. These tests shall be considered a part of the normal compression tests for the project. Allowable shrinkage limitations shall be specified herein.

C. The maximum concrete shrinkage for specimens cast in the laboratory from the trial batch, as measured at 21-day drying age or at 28-day drying age, shall be 0.036 percent or 0.042 percent, respectively. The Contractor shall only use a mix design for construction that has first met the trial batch shrinkage requirements.

D. The maximum concrete shrinkage for specimens cast in the field shall not exceed the trial batch maximum shrinkage requirement by more than twenty-five percent (25%).

E. If the required shrinkage limitation is not met during construction, the Contractor shall take all necessary action, at not additional cost to the Owner, for securing the specified shrinkage requirements. These actions may include changing the source of aggregates, cement and/or admixtures; reducing water content ratio; washing or aggregate to reduce fines; increasing the number of construction joints; modifying the curing requirements; or other actions designed to minimize shrinkage or the effects of shrinkage.

2.7 CEMENT GROUT

A. Cement grout materials shall be as specified in Section 03 60 00 - Grout.

PART 3 EXECUTION

3.1 EXAMINATION

A. Section 01 00 00 - Administrative Requirements: Coordination and project conditions.

B. Verify requirements for concrete cover over reinforcement.

C. Verify anchors, seats, plates, reinforcement and other items to be cast into concrete are accurately placed, positioned securely, and will not interfere with placing concrete.

3.2 MIXING CONCRETE

A. Mixing equipment shall be subject to the Engineers approval. Mixers shall be of the stationary plant or truck mixer type. Adequate equipment and facilities shall be provided for accurate measurement and control of all materials and for readily changing the proportions of the material. The mixing equipment shall be maintained in good working order and shall be capable of combining the aggregates, cement and water within the specified time into a thoroughly mixed and uniform mass and of discharging the mixture without segregation. Cement and aggregate shall be proportioned by weight.

B. The batch plant shall be capable of controlling and delivering of all material to within one percent (1%) by weight of the individual material. If bulk cement is used, it shall be weighed on a separate visible scale that will accurately register the scale load at any stage of the weighing operation from zero to full capacity.

1. Cement shall not come in contact with aggregate or with water until the materials are in the mixer ready for complete mixing with all mixing water. The procedure of mixing cement with sand or with sand and coarse aggregate for delivery to the jobsite for final mixing and an addition of mixing water will not be permitted. Retempering of concrete (addition of water to previously prepared concrete mix) will not be permitted. The entire batch shall be discharged before recharging. The volume of the mixed material per batch shall not exceed the manufacturers rated capacity of the mixer.

2. Each mixer shall be equipped with a device for accurately measuring and indicating the quantity of water entering the concrete, and the operating mechanism shall be such that leakage will not occur when the valves are closed. Each mixer shall be equipped with a device for automatically measuring, indicating and controlling the time required for mixing. This device shall be

interlocked to prevent the discharge of concrete from the mixer before the expiration of the mixing period.

3. Transit-mixed concrete shall be mixed and delivered in accordance with ASTM C94. After the drum is once started, it shall be revolved continuously until it has completely discharged its batch. Water shall not be admitted to the mix until the drum has started revolving. The right is reserved to increase the required minimum number of revolutions allowed, if necessary, to obtain satisfactory mixing, and the Contractor will not be entitled to additional compensation because of such an increase or decrease.

C. Mixed concrete shall be delivered to the site of the work and discharge shall be completed within one (1) hour after the addition of the cement to the aggregates. In hot weather or under conditions contributing to quick stiffening of the concrete, or when the temperature of the concrete is 85 degrees F. or above, the time between the introduction of the cement to the aggregates and discharge shall not exceed forty-five (45) minutes. The use of non-agitating equipment for transporting concrete will not be permitted.

D. Truck mixers shall be equipped with counters so that the number of revolutions of the drum may be readily verified. The counter must be capable of being reset and shall be actuated at the time of starting mixers at mixing speeds. Concrete shall be mixed in a truck mixer for not less than seventy (70) revolutions of the drum or blades at the rate of rotation designated by the manufacturer of equipment. Additional mixing, if any, shall be at the speed designated by the manufacturer of the equipment as agitating speed. All materials including mixing water shall be in the mixer drum before actuating the revolution counter for determining the number of revolution of mixing.

3.3 PREPARATION OF SURFACES FOR CONCRETING

A. Earth surfaces shall be thoroughly and uniformly wetted by sprinkling prior to the placing of any concrete. These surfaces shall be kept moist by frequent sprinkling up to the time concrete is placed thereon. The surface shall be free from standing water, mud and debris at the time of placing concrete.

B. The surfaces of all horizontal construction joints shall be cleaned of all latence, loose or defective concrete and foreign material. Such cleaning shall be accomplished by sandblasting followed by thorough washing. All pools of water shall be removed from the surface of construction joints before the new concrete is placed.

C. No concrete shall be placed until all formwork, installation of parts to be embedded, reinforcement steel and preparation off surfaces involved in the placing have been completed and accepted by the Engineer at least four (4) hours before placement of concrete. All reinforcement, anchor bolts, sleeves, inserts and similar items shall be set and secured in the forms where shown or by shop drawings and shall be acceptable to the Engineer before any concrete is placed. Accuracy of placement is the responsibility of the Contractor. All surfaces of embedded items that have become encrusted with dried grout from concrete previously placed shall be cleaned of all such grout before the surrounding or adjacent concrete is placed.

D. All form surfaces in contact with the concrete shall be thoroughly cleaned of all previous concrete, dirt and other surface contaminants prior to use. Damaged form surfaces shall not be used.

1. Wood form surfaces in contact with the concrete shall be coated with an approved release agent prior to form installation. The release agent shall be non-staining and non-toxic after thirty (30) days. Mill scale and other ferrous deposits shall be sandblasted or otherwise removed from the contact surface of steel forms.

2. All steel forms shall have the contact surfaces coated with an approved release agent. The release agent shall be effective in preventing discoloration of the concrete from rust and shall be non-toxic after thirty (30) days.

E. Where concrete is to be cast against old existing concrete, the old concrete shall be thoroughly roughened to exposed, hard aggregate by sandblasting or chipping. Any additional surface preparation shall be as called for in the drawings.

F. No concrete shall be placed in any structure until all water entering the space to be filled with concrete has been properly cut off or diverted out of the forms and clear of the work. No concrete shall be deposited under water or allowed to rise on any concrete until the concrete has attained its initial set. Pumping or other necessary dewatering operations for removing ground water, if required, shall be the responsibility of the Contractor and will be subject to review by the Engineer.

G. Pipe, conduit, dowels, sleeves and other ferrous items required to be embedded in concrete construction shall be adequately positioned and supported prior to placement of concrete. There shall be a minimum of 2-inches clearance between embedded items and any of the concrete reinforcement. Securing embedments in position by wiring or welding them to the reinforcement will not be permitted.

3.4 PLACING CONCRETE

A. No concrete shall be placed without prior inspection of the forms, reinforcing and embedded items and approval from an authorized representative of the Engineer. The Contractor shall notify the Engineer at least twenty-four (24) hours in advance of any scheduled concrete placement and shall call for final inspections no later than four (4) hours in advance of the scheduled placement. The Contractor shall notify the Engineer at least two (2) hours in advance of setting the opposite side of wall forms so that the construction joint preparation, water stop installation and reinforcing steel inspections can be conducted. It is the Contractors responsibility to see that the forms are properly cleaned and oiled before being set, the construction joints properly prepared, reinforcing steel is securely and properly supported in the correct position and that all embedment items including electrical conduit is correctly installed before calling for inspections. The Engineer may at his option require the use of placement cords if deemed necessary.

B. Placement of concrete shall conform to the requirements and recommendations of ACI 301, 304 and 318, except as modified herein.

C. Concrete, which upon or before placing is found not to conform to the requirements specified herein, shall be rejected and immediately removed from the Work. Concrete which is not placed in accordance with these specifications, or which is of inferior quality, shall be removed and replaced at the expense of the Contractor.

D. No concrete shall be placed during rain or snow storms, unless completely covered to prevent storm water from coming in contact with it. Sufficient protective covering material shall be kept on hand at all times should rain or snow storms arise during concrete placement operations.

E. Concrete shall be deposited at or near its final position to avoid segregation caused by rehandling or flowing. Concrete shall not be deposited in large quantities in one place and worked along the forms with vibrator or other means. Concrete shall be uniformly distributed during the placing process and in no case after depositing shall any portion be displaced in the forms more than 2-feet in horizontal direction. Concrete shall be deposited in forms in horizontal layers not to exceed 24-inches in depth and shall be brought up evenly in all parts of the form. The rate of placement of concrete in forms shall not exceed 5-feet of vertical rise per hour. As the concrete is placed it shall be consolidated thoroughly and uniformly by mechanical vibration to secure a dense mass, close bond with reinforcement and other embedded items and smooth surface. The mechanical vibrator shall penetrate not only the freshly placed concrete, but also the previously placed lift to ensure the lifts become monolith. New concrete shall be placed against previously placed concrete, not away from it. When concrete is placed on a slope, placement shall begin at the lower end of the slope and progress to the upper end for the full width of the placement. Consolidation by mechanical vibration shall follow directly behind placement and the rate of placement shall never get ahead of the consolidation crew. Concrete placement shall continue without avoidable interruption, in a continuous operation until the end of the placement is reached.

F. The drop of concrete into slab or wall forms shall be vertical. Concrete shall not be dropped through reinforced steel, but deposited in forms using a hopper with a drop chute to avoid segregation and to keep mortar from coating the reinforcement steel and forms above the in-place concrete. In no case shall the free fall of concrete exceed 4-feet below the end of the hopper or chute.

G. If it takes more than 20-minutes to get back to place concrete over concrete previously placed, the depth of the layers being placed at one time shall be reduced, and/or placing equipment increased, until it is possible to return with the placing operation to previously placed concrete within 20-minutes. If concrete is to be placed over previously poured concrete and more than 20-minutes have elapsed, then a layer of grout not less than 1/2-inch thick shall be spread over the surface before placing the additional concrete.

H. The placement of concrete for slabs, beams or walkways cast monolithically with walls or columns shall not commence until the concrete in the walls or columns has been allowed to set and shrink. The time allowed for shrinkage shall be not less than one (1) hour.

I. Concrete shall be placed with the aid of approved mechanical vibrators. Vibration shall be supplemented by manual forking or spading adjacent to the forms on exposed faced in order to secure smooth dense surfaces. The concrete shall be thoroughly consolidated around reinforcement, pipes or other shapes built into the work. The vibration shall be sufficiently intense to cause the concrete to flow and settle readily into place and to visibly affect the concrete over a radius of at least 18-inches.

   1. Sufficient vibrators shall be on hand at all times to vibrate the concrete as placed. In addition to the vibrators in actual use while concrete is being placed, the Contractor shall have on hand one (1) spare vibrator in serviceable condition. No concrete shall be placed until it has been ascertained that all vibrating equipment, including spares, is in serviceable condition.

J. Special care shall be taken to place the concrete solidly against the forms so as to leave no voids. Every precaution shall be taken to make all concrete solid, compact and smooth, and if for any reason the surfaces or interiors have voids or are in any way defective, such concrete shall be repaired as directed by the Engineer. No defective work shall be patched or repaired without the prior inspection and approval of the Engineer.

K. The temperature of concrete when it is being placed shall be not more than 90 degrees F. nor less than 40 degrees F. in moderate weather, and not less than 50 degrees F. in weather during which the mean daily temperature drops below 40 degrees F. Concrete ingredients shall not be heated to a temperature higher than that necessary to keep the temperature of the mixed concrete, as placed, from falling below the specified minimum temperature. If concrete is placed when the weather is such that the temperature of the concrete would exceed 90 degrees F., the Contractor shall employ effective means, such as precooling of aggregates and mixing water using ice or placing at night, as necessary to maintain the temperature of the concrete, as it is placed, below 90 degrees F. The Contractor shall be entitled to no additional compensation on account of the foregoing requirements.

L. Concrete shall not be placed on a frozen subgrade or subgrade that contains frozen materials. All ice and snow shall be removed from inside forms and from reinforcing steel and embedded items. The temperature of all surfaces that the concrete will contact shall be raised above the freezing point for at least 12-hours prior to placing new concrete.

1. The minimum temperature of fresh concrete as mixed shall be 60 degrees F. for ambient temperature above 30 degrees F.; 65 degrees F. for ambient temperature 0 degrees F. to 30 degrees F.; and 70 degrees F. for ambient temperature below 0 degrees F. The minimum temperature of fresh concrete after placing shall be 55 degrees F. for the first 72-hours.

2. The use of calcium chloride shall not be permitted.

3. In general, the Contractor shall adhere to the recommendations as outlined in ACI Standard 306 for cold weather concreting, except as required herein.

3.5 PUMPING OF CONCRETE

A. Pumping of concrete will be permitted only with the Engineer's approval. The pumping equipment must have two (2) cylinders and be designed to operate with one (1) cylinder only in case the other one is not functioning. In lieu of this requirement, the Contractor shall have a standby pump or crane and concrete bucket on site during pumping to provide assurance the concrete will be placed without cold joints in the event of pumping equipment breakdown. The minimum diameter of the hose (conduits) shall be 4-inches. Pumping equipment and hoses (conduits) that are not functioning properly, shall be replaced. Aluminum conduits for conveying the concrete will not be permitted.

B. Concrete samples for slump and test cylinders will be taken at the discharge end of the pumping conduit.

3.6 ORDER OF PLACING CONCRETE

A. The order of placing concrete in all parts of the work shall be acceptable to the Engineer. In order to minimize the effects of shrinkage, the concrete shall be placed in units as bounded by construction joints shown. The placing of units shall be done by placing alternate units in a manner such that each unit placed shall have cured at least 7-days before the contiguous unit or units are placed, except that the corner sections of vertical walls shall not be placed until the two (2) adjacent wall panels have cured at least 14-days.

B. The surface of the concrete shall be level whenever a run of concrete is stopped. To ensure a level, straight joint on the exposed surface of walls, a wood strip at least 3/4-inch thick shall be tacked to the forms on these surfaces. The concrete shall be carried about 1/2-inch above the underside of the strip. About one (1) hour after the concrete is placed, the strip shall be removed and any irregularities in the edge formed by the strip shall be leveled with a trowel.

3.7 TAMPING AND VIBRATING

A. As concrete is placed in the forms or in excavations, it shall be thoroughly settled and compacted, throughout the entire depth of the layer which is being consolidated, into a dense, homogeneous mass, filling all corners and angles, thoroughly embedding the reinforcement, eliminating rock pockets and bringing only a slight excess of water to be exposed surface of concrete during placement. Vibrators shall be high speed power vibrators (8,000 to 10,000 rpm) of an immersion type in sufficient number and with (at least one) standby units as required.

B. Care shall be used in placing concrete around waterstops. The concrete shall be carefully worked by rodding and vibrating to make sure that all air and rock pockets have been eliminated. Where flat-strip type waterstops are horizontal, the concrete shall be worked under the waterstops by hand, making sure that all air and rock pockets have been eliminated. Concrete surrounding the waterstops shall be given additional vibration, over and above that used for adjacent concrete placement to assure complete embedment of the waterstops in the concrete.

C. Concrete in walls shall be internally vibrated and at the same time rammed, stirred or worked with suitable appliances, tamping bars, shovels or forked tools until it completely fills the forms or excavations and closes snugly against all surfaces. Subsequent layers of concrete shall not be placed until the layers previously placed have been worked thoroughly as specified. Vibrators shall be provided in sufficient numbers, with standby units as required, to accomplish the results herein specified with fifteen (15) minutes after concrete of the prescribed consistency is placed in the forms. The vibrating head shall be kept from contact with the surfaces of the forms. Care shall be taken not to vibrate concrete excessively or to work it in any manner than causes segregation of its constituents.

3.8 FINISHING CONCRETE SURFACES

A. General: Surfaces shall be free from fins, bulges, ridges, offsets, honeycombing or roughness of any kind, and shall present a finished, smooth, continuous hard surface. Allowable deviations from plumb or level and from the alignment, profiles and dimensions shown are defined as tolerances and are specified in Paragraph 1.5, herein. These tolerances are to be distinguished from irregularities in finish as described herein. Aluminum finishing tools shall not be used.

B. Unformed Surfaces: After placing and consolidating concrete, all unformed top surfaces of slabs, walls, curbs, gutter and steps, shall be brought to a uniform finished surface. The classes of finish specified for unformed concrete surfaces are defined as follows:

1. Finish U1 (screeded concrete): Sufficient leveling and screeding to produce an even, uniform surface with surface irregularities not to exceed 3/8-inch. No further special finish is required.

2. Finish U2 (floated surface): After sufficient stiffening of the screeded concrete, surfaces shall be float finished with wood or metal floats or with a finishing machine using float blades. Excessive floating or surfaces while the concrete is plastic and dusting of dry cement and sand on the concrete surface to absorb excess moisture will not be permitted. Floating shall be the minimum necessary to produce a surface that is free from screed marks and is uniform texture. Surface irregularities shall not exceed 1/4-inch. Joints and edges shall be tooled where shown or as determined by the Engineer.

3. Finish U3 (steel trowel finish): After the floated surface (as specified for Finish U2) has hardened sufficiently to prevent excess of fine material from being drawn to the surface, steel troweling shall be performed with firm pressure such as will flatten the sandy texture of the floated surface and produce a dense, uniform surface free from blemishes, ripples and trowel marks. The finish shall be smooth and free of all irregularities.

4. Finish U4 (light broom finish): Steel trowel finish (as specified for Finish U3) without local depressions or high points. In addition, the surface shall be given a light hairbroom finish with brooming perpendicular to drainage unless otherwise shown. The resulting surface shall be rough enough to provide a non-skid finish.

C. The schedule for finished unformed surfaces shall be as follows:

Unformed Concrete Surface Schedule

Area	Finish
Grade slabs and foundations to be covered with concrete or fill material.	U1
Floor slabs to be covered with grouted tile or topping grout and slabs to be covered with built-up roofing.	U2
All building and machine room floors, basin floors not receiving a grout topping, channel floors, top of interior walls, top of interior curbs, steps and walkways.	U3
Exterior walkways, curb, gutter, sidewalk and steps, top of valve or meter vaults, electrical pull boxes and catch basins.	U4

D. Floor Sealer Hardener (Surface Applied):

1. Floor hardener shall be applied where shown or noted on the drawings.

2. Floors to receive hardener shall be cured, cleaned and dry with all work above them completed. Apply zinc and/or magnesium fluosilicate evenly, using three (3) coats, allowing 24-hours between coats.

3. The first coat shall be 1/3 strength, second coat 1/2 strength and third coat shall be 2/3 strength. Each coat shall be applied so as to remain set on the concrete surface for fifteen (15) minutes. If sodium silicate is used, it shall be applied evenly, using three (3) coats, allowing twenty-four (24) hours between coats, and the material shall be applied full strength a the rate of one (1) gallon per 300 square feet. Approved proprietary hardeners shall be applied in conformance with the manufacturers' instruction. After the final coat is completed and dry, surplus hardener shall be removed from the surface by scrubbing and mopping with water.

E. Formed Surfaces: Immediately following the removal of forms, the concrete shall be inspected for defects such as rock pockets, grout loss, damage from stripping forms, surface defects such as fins, offsets, bulges, excessive bug-holes and stains. All defective concrete work shall be removed and replaced or repaired to the satisfaction of the Engineer. Any work which has not been constructed in accordance with the plans and specifications will be considered defective.

Correction of defective work shall be as directed by the Engineer and specified herein. No defective work shall be patched, repaired or covered without prior inspection and approval of the Engineer.

Holes left by tie-rod cones or taper ties shall be reamed with suitable toothed reamers so as to leave the surfaces of the holes clean and rough. These holes then shall be repaired in an approved manner with non-metallic grout.

The classes of formed concrete surfaces are defined as follows:

1. <u>Finish F1</u>: No special treatment is required after form removal except for curing, repair of defective concrete treatment of surface defects, removal of fins and projections, filling of tie holes and filling of depressions and bug-holes 3/8-inch or larger in width or depth with mortar.

2. <u>Finish F2</u>: All defective concrete shall be repaired, all fins, offsets, bulges and projections ground smooth, filling of tie holes and filling of depressions and bug-holes 1/4-inch or larger in width or depth with mortar.

3. <u>Finish F3</u>: All defective concrete shall be repaired, all fins, offsets, bulges and projections ground smooth and tie holes filled with grout. The entire surface shall then receive a light stoning or grinding using a No. 50 or No. 60 grit carborundum stone or grinding wheel to remove any latence and curing film and to open up bug-holes hidden beneath the thin surface grout film. The surface shall then be given a stoned-sand type architectural finish as follows:

   a. The concrete surface shall be pre-wet for several hours or overnight before treatment.

   b. While the surface is still damp, spread a sand mix, consisting of one (1) part of Type II Cement and one to one and a half (1 to 1-1/2) parts of fine sand passing the No. 70 screen mixed with enough water and an emulsified bonding agent to have the consistency of thick cream. The sand mix should be spread thinly over the damp surface with a rubber float and rubbed in over the entire area leaving only a minimum amount of material on the surface necessary to produce a sand texture, approximately 1/32-inch in thickness.

c. The surface shall be kept continually damp for seventy-two (72) hours following this finish treatment.

F. The schedule for formed surface finish shall be as follows:

Formed Concrete Surface Schedule

Area	Finish
Formed concrete surfaces to be covered by backfill or coated with below grade waterproofing systems.	F1
Formed concrete surfaces in water channels, below water surface of basins, inside meter and valve vaults, inside cells of hydraulic splitter boxes and weirs.	F2
Formed concrete surfaces inside buildings and machine rooms and all exposed exterior surfaces of foundations, basins, vaults, hydraulic structures and curbs.	F3

3.9 CURING AND DAMPPROOFING

A. General: All concrete shall be cured for not less than ten (10) days in warm to hot weather and fourteen (14) days in cold weather after placing, unless otherwise indicated by the Engineer, in accordance with the methods specified herein for the different parts of the Work, and described in detail as follows:

1. Water Curing: Keep the concrete structures thoroughly and continuously wet and covered for at least 7 days. Place and anchor covers, mats, and sheeting to ensure continuous contact with the concrete surfaces. Use one of the water curing methods as detailed in ACI 308.1.

2. Curing Compound: The surface shall be sprayed with a liquid membrane-forming curing compound applied in accordance with the manufacturers printed instructions.

a. Care shall be exercised to avoid damage to the seal during the curing period. Should the seal be damaged or broken before the expiration of the curing period, the break shall be repaired immediately by the application of additional curing compound over the damaged portion.

b. Curing compound specified shall be applied as soon as the concrete has hardened enough to prevent marring on unformed surfaces, and within one (1) hour after removal of forms from contact with formed surfaces. Repairs to formed surfaces shall be made within the said one (1) hour period. If repairs cannot be made with the one (1) hour period they shall be delayed until after the curing compound has been applied. When repairs are to be made to an area on which curing compound has been applied, the area involved shall first be sandblasted to remove the curing compound, following which repairs shall be made as specified herein.

3. Cold weather is defined as when the temperature reaches or goes below 35 degrees F for one (1) hour during any 24-hour period during the curing period.

B. Method 2 shall be used for wall sections with forms removed, encasement concrete and all concrete surfaces where Method 1 is not feasible.

3.10 PROTECTION

A. The Contractor shall protect all concrete against injury or damage from excessive heat, lack of moisture, overstress or any other cause until final acceptance by the Owner. Particular care shall be taken to prevent the drying of concrete and to avoid roughening or otherwise damage to finish surfaces.

B. Finished floor slabs in buildings and machine rooms shall be suitably protected from wear or damage from construction operations. The Contractor shall not use newly finished floors or buildings for machine assembly, fabrication, pipefitting, curing or welding operations without covering the working area with plastic sheets and/or plywood. Any concrete found to be damaged or which may have been originally defective or which becomes defective at any time prior to the final acceptance of the completed work, or which departs from the established line or grade, or which, for any other reason, does not conform to the requirements of the Contract Documents, shall be satisfactorily repaired or removed and replaced with acceptable concrete at the Contractor's expense.

C. Immediately following the first frost in the fall, the Contractor shall be prepared to protect all concrete against freezing.

3.11 CURING IN COLD WEATHER

A. After the first frost, and until the mean daily temperature in the vicinity of the worksite falls below 40 degrees F for more than one (1) day, the concrete shall be protected against freezing temperatures for not less than forty-eight (48) hours after it is placed. After the mean daily temperature in the vicinity of the worksite falls below 40 degrees F. for more than one (1) day, the concrete shall be maintained at a temperature not lower than 50 degrees F. for at least seventy-two (72) hours after it is placed.

B. Discontinuance of protection against freezing temperatures shall be such that the drop in temperature of any portion of the concrete will be gradual and will not exceed 40 degrees F. over a (3) three day duration.

C. Where artificial heat is employed, special care shall be taken to prevent the concrete from drying. Use of unvented heaters will be permitted only when unformed surfaces of concrete adjacent to the heaters are protected from drying and excessive carbon dioxide atmosphere by application of curing Method 2 or Method 3, as specified under Article 3.9, Paragraph A herein.

3.12 REPAIR OF DEFECTIVE CONCRETE

A. No concrete repairs shall be made until after inspection and approval of the method of repair by the Engineer. In no case will extensive patching of honeycombed concrete be permitted. Concrete containing extensive voids, holes, honeycombing or similar depression defects shall be completely removed and replaced. Concrete containing minor voids, holes, honeycombing or similar depression defects shall be repaired as specified herein. All concrete repairs and replacements shall be promptly executed by the Contractor at its own expense.

B. The repair of holes left by rock pockets, penetrations, tie rods or other reasons will require the use of non-shrink, non-metallic grout material.

END OF SECTION

SECTION 03 60 00

GROUT

PART 1 GENERAL

1.1 SUMMARY

A. The Contractor shall furnish, place, finish and cure the following types of grouting mortars as called for herein and as shown in the Contract Documents.

1. Non-Shrink Grout: This type of grout shall be used wherever grout is shown or called for in the Contract Documents, unless another type is specifically referenced.

2. Topping Grout: This type of grout shall be used for grouting in submerged applications, such as clarifier bottoms.

3. Epoxy Grout: This type of grout shall be used for anchor bolt or reinforcing steel embedment, repairs and resurfacing.

B. Related Sections:

1. Section 03 30 00 - Cast-in-Place Concrete.

1.2 REFERENCES

A. American Concrete Institute:

1. ACI 301 - Specifications for Structural Concrete.

2. ACI 318 - Building Code Requirements for Structural Concrete.

B. American Society of Testing and Materials:

1. ASTM C33 - Standard Specification for Concrete Aggregates.

2. ASTM C109 - Standard Test Method for Compressive (Latest Edition) Strength of Hydraulic Cement Mortars (Using 2-inch or 50-mm Cube Specimens).

3. ASTM C150 - Standard Specification for Portland Cement.

4. ASTM C827 - Test Method for Change in Height at Early Ages of Cylindrical Specimens from Cementitious Mixtures.

C. U. S. Army Corps of Engineers Concrete Research Division (CRD):

1. CRD C621 - Non-Shrink Grout.

1.3 SUBMITTALS

A. Non-Shrink Grout: Submit manufacturers' technical data including compressive strength and expansion data at plastic, flowable and fluid consistencies. Also submit manufacturer's applications manual containing instructions and recommendations for mixing, handling, placement and appropriate uses for each type of non-shrink grout used in the work.

B. Topping Grout: Provide certified mix design including proportions and gradations of all materials and compressive strength test results from at least one (1) trial batch. Tests shall be performed by a certified testing laboratory. All costs for such mix design and trial batch tests shall be borne by the Contractor.

C. Epoxy Grout: Submit manufacturers' technical data including strengths and application manual of instructions for mixing, handling and placing.

D. Cement Grout: Submit manufacturers' technical data including compressive strength and expansion data at plastic, flowable and fluid consistencies. Also submit manufacturer's applications manual containing instructions and recommendations for mixing, handling, placement and appropriate uses for each type of cement grout used in the work.

1.4 QUALITY ASSURANCE

A. Mix design tests for topping grout shall be performed per the standards referenced herein.

B. During the progress of construction, the Engineer may have tests made of each type of grout used in the work to ensure compliance with the Contract Documents. These tests will be made in accordance with the standards referenced herein. The test expense during construction, except for the mix design and trial batch tests, will be borne by the Owner. The costs of additional tests including non-destructive tests and core drilling needed to verify or investigate the quality of questionable work or material shall be borne by the Contractor.

C. Grout for testing shall be supplied by the Contractor at no cost to the Owner.

D. If any grout fails to meet the requirements of these specifications, immediate corrective action shall be taken for all subsequent batches. Grout already in place that fails to meet these requirements is subject to removal and replacement with all costs borne by the Contractor.

E. Construction tolerances shall be as specified in Section 03 30 00 - Cast-In-Place Concrete, except as modified herein and elsewhere in the Contract Documents.

PART 2 PRODUCTS

2.1 NON-SHRINK GROUT

A. Non-shrink grout shall be a prepackaged, inorganic, non-gas-liberating, non-metallic, cement-based grout requiring only the addition of water. Manufacturer's instructions shall be printed on each bag or other container in which the materials are packaged.

B. Non-shrink grouts for use as herein specified shall conform to the Corps of Engineers specifications for Non-Shrink Grout, CRD-C621-85 and to these specifications. The grout shall have a 28-day compressive strength of 6,000 psi or greater.

C. Non-shrink grouts shall be as manufactured by: Tremcrete Systems Inc., Woodland, California; Gifford-Hill & Company, Inc., Dallas, Texas; or approved equal.

2.2 TOPPING GROUT

A. Grout for topping of slabs and concrete fill for built-up surfaces of tank, channel, and basin bottoms shall be composed of cement, fine aggregate, coarse aggregate, water, and admixtures proportioned and mixed as indicated herein. All materials and procedures specified for concrete in Section 03 30 00 shall apply except as indicated otherwise herein.

B. Topping grout and concrete fill shall contain a minimum of 564 pound of cement per cubic yard with a maximum water cement ratio of 0.45. Where concrete fill is thicker than 3 inches, structural concrete as indicated in Section 03 30 00 may be used when accepted by the Engineer.

C. Coarse aggregate shall be graded as follows:

U.S. STANDARD SIEVE SIZE	PERCENT BY WEIGHT PASSING
1/2"	100
3/8"	90-100
No. 4	20-55
No. 8	5-30
No. 16	0-10
No. 30	0

D. Final mix design shall be as determined by trial mix design under supervision of the approved testing laboratory.

E. Strength: Minimum compressive strength at 28-days shall be 4,000 psi.

2.3 EPOXY GROUT

A. Epoxy grout shall be a pourable, non-shrink, one-hundred percent (100%) solids system. The epoxy grout system shall have three components; resin, hardener, and specially blended aggregate, all premeasured and prepackaged. The resin component shall not contain any non-reactive diluents. Resins containing butyl glycidyl ether (BGE) or other highly volatile and hazardous reactive diluents are not acceptable. Variation of component ratios is not permitted unless specifically recommended by the manufacturer. The chemical formulation of the epoxy grout shall be that recommended by the manufacturer for the particular application. Manufacturer’s instructions shall be printed on each container in which the materials are packaged.

B. The mixed epoxy grout system shall have a minimum working life of 45 minutes at 75 degrees F. The epoxy grout shall develop a minimum compressive strength of 5,000 psi in 24-hours and 10,000 psi in 7-days.

C. Epoxy grouts shall be as manufactured by: Unisorb; or approved equal.

2.4 CEMENT GROUT

A. Portland Cement: ASTM C150, Type I and II.

B. Water:

1. Potable; containing no impurities, suspended particles, algae or dissolved natural salts in quantities capable of causing:

a. Corrosion of steel.

b. Volume change increasing shrinkage cracking.

c. Efflorescence.

d. Excess air entraining.

C. Fine Aggregate:

1. Washed natural sand.

2. Gradation in accordance with ASTM C33 and represented by smooth granulometric curve within required limits.

3. Free from injurious amounts of organic impurities as determined by ASTM C40.

D. Mix:

1. Portland cement, sand and water. Do not use ferrous aggregate or staining ingredients in grout mixes.

2. Water content shall be such that the grout can be readily spread, yet not wet enough to cause trouble with surface water or laitance, or failure to stay in place after screeding. All grout mixes and mixing procedures shall be submitted in accordance with Section 01 00 00 - Contractor Submittals, and shall be subject to review and approval by the Engineer prior to commencing the grouting operations.

E. The minimum compressive strength at 28 days shall be 4,000 psi.

F. Procedures for Grout placement shall be approved by the equipment supplier, to ensure that no equipment is overstressed, as well as proper placement tolerances. Equipment Supplier shall have final say on grouting procedures and final tolerances.

2.5 CONSISTENCY

A. The consistency of grouts shall be that necessary to completely fill the space to be grouted for the particular application. Dry pack consistency is such that the grout is plastic and moldable but will not flow. Where "dry pack" is called for in the Contract Documents, it shall mean a grout of that consistency; the type of grout to be used shall be as required for the particular application.

B. The slump for topping grout and concrete fill shall be adjusted to match placement and finishing conditions but shall not exceed 4 inches.

2.6 CURING MATERIALS

A. Curing materials shall be as specified in Section 03 30 00 - Cast-In-Place Concrete, for cement topping grout and as recommended by the manufacturer of non-shrink grouts.

PART 3 EXECUTION

3.1 PREPARATION

A. All surface preparation, curing, and protection of cement grout shall be as specified in Section 03 30 00. The finish of the grout surface shall match that of the adjacent concrete

B. Remove defective concrete, laitance, dirt, oil, grease and other foreign material from concrete surfaces by brushing, hammering, chipping or other similar means until sound, clean concrete surface is achieved.

C. Rough concrete lightly, but not enough to interfere with placement of grout.

D. Remove foreign materials from metal surfaces in contact with grout.

E. Align, level and maintain final positioning of components to be grouted.

F. Saturate concrete surfaces with clean water; remove excess water, leave none standing.

3.2 PLACING NON-SHRINK AND EPOXY GROUT

A. All forming, mixing, surface preparation, handling, placing, consolidation, curing, and other means of execution for prepackaged grouts shall be done according to the instructions and recommendations of the manufacturer.

B. Place grout material quickly and continuously.

C. Do not use pneumatic-pressure or dry-packing methods.

D. Apply grout from one side only to avoid entrapping air.

E. Do not vibrate placed grout mixture, or permit placement when area is being vibrated by nearby equipment.

F. Thoroughly compact final installation and eliminate air pockets.

G. Do not remove leveling shims for at least 48 hours after grout has been placed.

3.3 PLACING TOPPING GROUT

A. All mechanical, electrical, and finish work shall be completed prior to placement of topping or concrete fill. The base slab shall be given a roughened textured surface by sandblasting or hydroblasting exposing the aggregates to ensure bonding to the base slab.

B. The minimum thickness of grout topping and concrete fill shall be one inch, unless otherwise indicated on the Design Drawings. Where the finished surface of concrete fill is to form an intersecting angle of less than 45 degrees with the concrete surface it is to be placed against, a key shall be formed in the concrete surface at the intersection point. The key shall be a minimum of 3-1/2-inches wide by 1-1/2-inches deep.

C. The base slab shall be thoroughly cleaned and wetted prior to placing topping and fill. No topping concrete shall be placed until the slab is completely free from standing pools or ponds of water. A thin coat of neat Type II cement grout shall be broomed into the surface of the slab just before topping or fill placement. The topping and fill shall be compacted by rolling or tamping, brought to established grade, and floated. Grouted fill for tank and basin bottoms where scraping mechanisms are to be installed shall be screeded by blades attached to the revolving mechanism of the equipment in accordance with the procedures outlined by the equipment manufacturer after the grout is brought to the established grade.

D. Topping grout placed on sloping slabs shall proceed uniformly from the bottom of the slab to the top, for the full width of the placement.

E. The surface shall be tested with a straight edge to detect high and low spots which shall be immediately eliminated. When the topping and fill has hardened sufficiently, it shall be steel troweled to a smooth surface free from pinholes and other imperfections. An approved type of mechanical trowel may be used as an assist in this operation, but the last pass over the surface shall be by hand-troweling. During finishing, no water, dry cement or mixture of dry cement and sand shall be applied to the surface.

3.4 CONSOLIDATION

A. Grout shall be placed in such a manner, for the consistency necessary for each application, so as to assure that the space to be grouted is completely filled.

3.5 CURING

A. Immediately after placement, protect grout from premature drying, excessively hot or cold temperatures, and mechanical injury.

B. After grout has attained its initial set, keep damp for minimum of 7 days, or as otherwise indicated by the manufacturer.

END OF SECTION

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 <u>each</u> 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 13 34 20
PRE-CAST CONCRETE BUILDING FACILITY 900

PART 1 GENERAL

1.01 SUMMARY

A. Contractor to furnish pre-cast, post-tensioned concrete *transportable* building. Building to be delivered and placed on prepared crushed stone foundation in accordance with manufacturer's recommendations. Facility 900 to be EASI-SET brand Model 810 as manufactured by Lonestar Prestress Mfg., Inc., Houston, Texas, or approved equal. Building to be provided by manufacturer with all necessary openings as specified in conformance with manufacturer's structural requirements or approved equal.

1.02 CODES, STANDARDS AND REFERENCES

A. American Concrete Institute (ACI):

1. 318-02, Building Code Requirements for Structural Concrete.

B. American Society of Civil Engineers (ASCE):

1. 7-02, Minimum Design Loads for Buildings and Other Structures.

C. American Society for Testing and Materials (ASTM):

1. C150, Standard Specification for Type I and Type II – Low Alkali Portland Cement.
2. C33, Standard Specification for Concrete Aggregates.
3. A36, Standard Specification for Carbon Structural Steel.
4. A615, Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.
5. A706, Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement.
6. A416, Standard Specification for Steel Strand, Uncoated Seven-Wire for Prestressed Concrete.
7. A185, Standard Specification for Steel Welded Wire Fabric, Plain, for Concrete Reinforcement.
8. A307, Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength.
9. A123, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
10. A153, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.

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D. 2015 International Building Code (IBC).

E. 2015 IECC 2015 International Energy Conservation Code.

F. National Fire Protection Association (NFPA):

   1. 70, National Electrical Code, 2017 edition.

G. PCI Design Handbook, Precast/Prestressed Concrete Institute.

H. Underwriters Laboratories (UL):

   1. 752, Standard for Safety for Bullet Resisting Equipment, Underwriters Laboratories Inc. “Manual of Standard Practice”, Concrete Reinforcing Institute.

1.03 QUALITY ASSURANCE

A. Walls to be UL-752 Test Method Level 4 for bullet resistance, certified by an independent structural engineer.

B. Building fabricator must have a minimum of 5 years’ experience manufacturing pre-cast concrete buildings.

C. No alternate building designs to the pre-engineered EASI-SET building will be allowed unless preapproved by the Owner 10 days prior to the bid date.

1.04 DESIGN REQUIREMENTS

A. Dimensions

   1. Exterior: 8 feet wide by 10 feet long by 8 feet 8 inches high.
   2. Interior: 7 feet 6 inches wide by 9 feet 6 inches long by 8 feet 0 inches high.

B. Nomenclature:

   1. The long axis of the building will be oriented east-west on the site.

C. Standard Design Loads:

   1. Standard Wind Loading: 140 mph (ASCE 7-02, Category II, Exposure C, Enclosed Building).
   2. Standard Roof Live Load: 60 psf.
   3. Standard Floor Live Load: 250 psf.
   4. Seismic Design category D, Seismic use Group I.

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D. Roof: Roof panel shall be sloped 1 inch from front to back. The roof shall extend a minimum of 3 inches beyond the wall panel on each side and have a turndown design which extends 1/2 inch below the top edge of the wall panels to prevent water migration into the building along top of wall panels. Roof shall also have an integral architectural ribbed edge. Roof shall be water and weather tight.

E. Floor: There shall be a 1/2-inch deep recess, the width of the wall panels, cast into the floor. The 1/2-inch recess makes the interior floor surface 1/2-inch higher than the joint between the wall panel and floor slab preventing intrusion of water.

1. Provide floor penetrations to accommodate the following underground connections by others:
   a. Electrical:
      1) Two 2-inch power service entrance conduits.
      2) 4/0 AWG bare copper ground conductor.
      3) Three 1-inch tank instrumentation conduits.
      4) Two 1-inch radio conduits.
      5) One 1-inch heat trace circuit conduit.
   b. Plumbing:
      1) One 1-inch sample line.
      2) One 1-inch drain line.

F. Roof: Floor and wall panels must each be produced as single component monolithic panels. No roof, floor, or vertical wall joints will be allowed, except at corners. Wall panels shall set on top of floor slab.

1.05 SUBMITTALS

A. Shop Drawings of the Building:

1. Plan View:
   a. Drawn to scale at not smaller than 1/2 inch equals 1 foot 0 inches when plotted on 11-inch by 17-inch paper.
   b. Show installation of all accessories.
2. Exterior elevations.
3. General notes.
4. Panelboard schedule.

B. Building engineering calculations that are designed and sealed by a professional engineer, licensed in the state of manufacture, shall be submitted for approval.

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PART 2 PRODUCTS

2.01 MATERIALS

A. Concrete: Steel-reinforced, 6000 psi minimum 28-day compressive strength.

B. Reinforcing Steel: ASTM A615, Grade 60 or ASTM A185, Grade 80, unless otherwise indicated.

C. Post-tensioning Strand: 41K Polystrand CP5O, .50, 270 KSI, seven-wire strand, greased plastic sheath, (ASTM A416), roof and floor to be each post-tensioned by a single, continuous tendon. Said tendon shall form a substantially rectangular configuration having gently curving corners and a corner where the tendon members are anchored. Tendons shall be greased and enclosed within a sheath.

1. If post-tensioning is *not* used in the roof panel, the following guidelines must be followed to ensure a watertight roof design.
   a. The entire pre-cast concrete roof panel surface must be cleaned and primed with a material that prepares the concrete surface for proper adherence to the coating material.
   b. The entire pre-cast concrete roof panel surface shall be sealed with a .045 EPDM continuous membrane cemented to the concrete with a compound designed for this purpose.

D. Caulking: All joints between panels shall be caulked on the exterior and interior surface of the joints. Caulking shall be SIKAFLEX-IA elastic sealant, or equal. Exterior caulk joint to be 3/8-inch by 3/8-inch square so that sides of joint are parallel for correct caulk adhesion. Back of joint to be taped with bond breaking tape to ensure adhesion of caulk to parallel sides of joint and not the back.

E. Vents: Two screened aluminum vents to be in rear wall. Vents shall be SUNVENT No. 164FL, or equal.[HJ1]

F. Panel Connections: All panels shall be securely fastened together with 3/8-inch thick steel brackets. Steel is to be of structural quality, hot-rolled carbon complying with ASTM A36 and hot dipped galvanized after fabrication. All fasteners to be 1/2-inch diameter bolts complying with ASTM A307 for low-carbon steel bolts. Cast-in anchors used for panel connections to be Dayton-Superior No. F-63, or equal. All inserts for corner connections must be secured directly to form before casting panels. Floating of connection inserts will not be allowed.

2.02 ACCESSORIES

A. Door and Frame: Comply with Steel Door Institute "Recommended Specifications for Standard Steel Doors and Frames” (SDI-l00), and as herein specified. The building shall be equipped with double 3 feet 0 inches by 7 feet 0 inches by

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1-3/4-inch, 18-gauge steel doors, with insulated core and galvanized. Doors shall open as noted on Drawings. Frames shall be 16-gauge galvanized steel. Doors and frames shall be painted with one coat of rust inhibitor primer and one finish coat of epoxy paint, medium gray, if no other color is specified.

1. Provide the door on the west end of the building.

B. Door Hardware:

1. Handle: Lindstrum pull-handle stainless steel, 8-1/2 inches by 2 inches, or passage knob, or equal.
2. Lockset: Cal-Royal lever lock or Easi-Set, or equal.
3. Deadbolt: Yale or Easi-Set stainless steel keyed outside only, or equal.
4. Hinges: Hagar stainless steel five knuckle ball bearing with non-removable pins, or equal.
5. Threshold: Hagar or National Guard Products extruded aluminum with neoprene seal, or equal.
6. Overhead Door Holder: Yale surface-mounted overhead slide type with safety release, or equal.
7. Drip Cap: Hager or National Guard Products aluminum with stainless steel screws, or equal.
8. Door Closer: Norton 7500 or Yale 4410 with hold open, or equal.
9. Surface Bolts (Upper and Lower): Magnokrom Inc. 400-401 cadmium plated finish, or equal, as required for double doors.
10. Astragal: Galvanized steel, same finish and brand as door, as required for double doors.
11. Door Stop: Ives 445B26D brushed chrome (inactive leaf only), or equal, as required for double doors.

C. Heating, Ventilation, Air Conditioning:

1. Air Conditioning is not required for this facility.
2. Heating:
   a. Ceiling Suspended Electric Heater:
      1) 1.5 KW, 240 volt, single-phase, 60 Hertz.
      2) Steel Finned Tubular Element.
      3) Automatic reset thermal cutout.
      4) Outlet grille with louvered face.
      5) Wall-mounted thermostat near entrance door.
      6) NEMA 3R Disconnect.
      7) Mounting height not to exceed 10 foot.

D. Electrical:

1. General Requirements: In accordance with Sections 26 05 02, Basic Electrical Requirements, and 26 05 04, Basic Electrical Materials and Methods.

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2. Conductors: In accordance with Section 26 05 05, Conductors.
3. Grounding: In accordance with Section 26 05 26, Grounding and Bonding for Electrical Systems.
    a. Provide a main grounding bar on the interior building wall beneath the electrical panelboard.
4. Raceway and Boxes: In accordance with Section 26 05 33, Raceway and Boxes.
5. Panelboard:
    a. Provide one panelboard in accordance with Section 26 24 16, Panelboards.
        1) Tag No. PNL-900-01:
            a) 120/240V, single-phase, 100A bus and 60A main circuit breaker, 10kAIC.
            b) 18 branch circuit spaces.
            c) NEMA Type 1 enclosure
            d) Provide branch circuits as follows:
                (1) Lighting, 20A, 1P.
                (2) Interior Receptacles: 20A, 1P.
                (3) Exterior Receptacles: 20A, 1P, GFCI.
                (4) Heat Trace: 20A, 1P, GFI.
                (5) Radio: 20A, 1P.
                (6) Analyzer No. 1: 20A, 1P.
                (7) Analyzer No. 2: 20A, 1P.
                (8) Electric Unit Heater: 20A, 2P.
                (9) Four spare circuit breakers: 20A, 1P.
            e) Provide surge protective device in accordance with Section 26 43 00, Surge Protective Devices.
        2) Provide the panelboard on the south wall of the building, near the west end.
        3) Bond panelboard ground bar to main grounding bar in accordance with NEC. Use 4 AWG wire, minimum.
6. Wiring Devices:
    a. Provide in accordance with Section 26 27 26, Wiring Devices.
        1) Light Switch:
            a) Provide switch for interior luminaire on the interior wall of the building, to the south of the doorway.
        2) Receptacles:
            a) Provide one duplex receptacle on the south interior wall in the vicinity of the panelboard. The receptacle box may be connected to the panelboard with a short nipple.
            b) Provide one duplex receptacle on the north exterior wall of the building.

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7. Lighting:
   a. Provide in accordance with Section 26 50 00, Lighting.
      1) Interior Lighting:
         a) Provide one 48-inch linear LED ceiling-mounted luminaire.
            (1) Fiber-glass gasketed housing\and frosted polycarbonate lens.
            (2) Nominal Light Output: 3000 lumens.
            (3) Wide light distribution.
            (4) Color Temperature: 4000 degrees K.
            (5) Lithonia FEM L48 3000LM LPPFL WD 120 30K or approved equal.
      2) Exterior Lighting:
         a) Above the doorway, provide one outdoor LED wall sconce.
            (1) Full-cutoff optics.
            (2) Natural aluminum enclosure.
            (3) Nominal Light Output: 3000 lumens.
            (4) Forward throw light distribution.
            (5) Color Temperature: 4000 degrees K.
            (6) Motion and ambient light sensor.
            (7) Lithonia WST LED P2 40K VF 120 PIR DNAXD or approved equal.
            (8) Provide box embedded in building wall for mounting the luminaire.
         b) On the north exterior wall near the west end, provide one outdoor LED floodlight.
            (1) Natural aluminum enclosure.
            (2) Nominal light output: 10,000 lumens.
            (3) Flood distribution.
            (4) Color Temperature: 4000 degrees K.
            (5) Mounting: Integral slipfitter, 2-3/8-inch inside diameter. Mount to outside of wall, 7 feet 6 inches above bottom of floor elevation.
            (6) Visor for upper side of luminaire.
            (7) Controls: Spring-wound 60-minute timer switch in a weatherproof box (Intermatic FD60MHW or approved equal) mounted on the west exterior wall to the north of the doorway.
            (8) Mounting: Wall-mounted tenon, 2-3/8-inch outside diameter, 8-inch radius curve, natural aluminum finish. Provide wall penetration for routing branch circuit conductors.
            (9) Lithonia DSXF2 LED P2 40K FL 120 IS DNAXD with UBV visor and FRWB TD20 DNA wall tenon, or approved equal.

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2.03 FINISHES

A. Interior of Building: Smooth steel form finish on all interior panel surfaces.

B. Exterior of Building: Smooth steel form or troweled surface on all exterior panel surfaces.

1. Finish: Siloxane based, penetrating Clear Matte Sealer.

PART 3 EXECUTION

3.01 SITE PREPARATION REQUIREMENTS (MANUFACTURER'S RECOMMENDATION)

A. Facility 900 shall bear fully on firm undisturbed soils with an approved fill or pad. The turf shall be removed and a minimum 6-inch pad of approved fill material shall be placed. Where unacceptable material occurs, excavate and replace with an approved compacted fill material. The minimum recommended allowable bearing shall be 1,500 pounds per square foot.

B. No building shall bear directly on rock. Where rock is closer than 2 feet from the bottom of the building floor slab or foundation slab, it shall be undercut to a minimum of 2 feet below the building and replaced with an approved fill material.

C. Provide positive drainage for the fill, pad, and slab, as required.

D. Approved fill or pad material shall be stone which conforms to ASTM C33. Allowable sizes are No. 56, No. 67, No. 6, No. 7, and No. 8.

E. All fills, pads, or slabs shall he level to within a 0.042-foot (1/2-inch) differential over the entire building area.

F. The entire granular fill or pad shall be kept within the confines of the soil or other surrounding objects. Do not allow the fill or pad material to be undermined so that it may wash, erode or otherwise be undermined.

G. The finished floor slab elevation shall be above the exterior grade. The grade shall have positive slope and drainage away from the building at all points.

H. Stone base or pad shall be a minimum of 2 feet larger in length and width of building.

3.02 SITE PREPARATION REQUIREMENTS (POURED-IN-PLACE SLAB)

A. Facility 900 shall bear fully on an engineered concrete or asphalt slab. The slab shall be designed to support the anticipated load of the Facility 900 and its contents. The

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building shall be leveled, shimmed as required, and set in a grout bed sufficient to fill all cavities between the foundation slab and the building floor slab.

3.03 SITE PREPARATION REQUIREMENTS (CAST-IN-PLACE FLOOR)

A. Contractor to pour a concrete floor slab with turndown footing the same length and width of building. The floor slab shall be designed to support the anticipated load of the building walls and its contents.

B. The floor shall have a 1-1/2-inch deep recess, the width of the wall plus 3-1/2-inch wide cast into the floor around the perimeter except at doors. The 1-1/2-inch recess makes the interior floor surface 1-1/2 inches higher than the joint between the wall panel and the foundation preventing intrusion of water.

C. The finished floor slab elevation shall be above the exterior grade. The grade shall have a positive slope and drainage away from the building at all points.

D. Concrete slab to be steel reinforced and level within 1/8-inch in both directions. Footer depth and reinforcement to be in accordance with Drawings.

3.04 ACCESS

A. Contractor must provide level unobstructed area large enough for crane and tractor/trailer to park adjacent to pad. Crane must be able to place outriggers within 5 feet 0 inches of edge of pad and truck and crane must be able to get side-by-side under their own power. No overhead lines may be within 75-foot radius of center of pad.[HJ2]

END OF SECTION

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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 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].]**

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.

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.

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.

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.

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.

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.

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.

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.

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.

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 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 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 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 03
UNDER TANK CATHODIC PROTECTION SYSTEM

PART 1 GENERAL

1.01 SYSTEM DESCRIPTION

A. This section covers the Work necessary to furnish and install an impressed current cathodic protection system for the finish water reservoir bottom, complete.

B. The Contractor shall design and provide an impressed current cathodic protection system for surfaces of the reservoir floor in contact with foundation soil, complete and operable. Surfaces to be protected shall include the rebar in the concrete ring foundation for the tank as the rebar will be electrically continuous with the tank via the lightning protection system.

1.02 REFERENCES

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

1. NACE Standard, SP0193, Standard Practice External Cathodic Protection of On-Grade Carbon Steel Storage Tank Bottoms.
2. National Fire Protection Association (NFPA): 70, National Electrical Code (NEC).

1.03 DEFINITIONS

A. Lead, Lead Wires, Cable: Insulated copper conductor; the same as wire.

1.04 DESIGN REQUIREMENTS

A. The cathodic protection system shall be designed to prevent corrosion on the surfaces of the reservoir floor plates in contact with foundation soil. The cathodic protection design shall account for the additional surface area of the epoxy coated rebar in the support ring for the tank. The general dimensions of the reservoir are shown on the Drawings. Verify actual dimensions with the Engineer prior to cathodic protection design. The cathodic protection design shall account for epoxy coated rebar in the support ring for the tank.

B. Protection Criteria: The cathodic protection system shall be designed to maintain the potential of the protected surface, including rebar, more negative than -0.85 volt relative to a copper-copper sulfate reference electrode under IR drop-free conditions.

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1.05 SUBMITTALS

A. Shop Drawings:

1. Submit Shop Drawings of all equipment for approval before fabrication. Should an error be found in a Shop Drawing during installation of the equipment, the correction, including any field changes found necessary, shall be noted on the Drawing and resubmitted for approval.
2. Shop Unless otherwise noted herein, catalog cuts, bulletins, brochures, or similar will be sufficient for some items of material is submitted together with clean indication of the specific item or items, or class of items proposed, in order to establish written record of the Contractor’s intent. Any material installation without adherence to this procedure will be subject to removal, rework, and replacement at no increase cost to the Owner.
3. Cathodic Protection Specialist: Submit qualifications and experience record of proposed cathodic protection specialist prior to beginning the design.
4. Calculations: Submit design calculations for the cathodic protection system covered in this section.
5. Record Drawings: Show the location, size, and description of the complete cathodic protection system.

B. Quality Assurance/Quality Control Submittals:

1. Cathodic Protection Specialist qualifications.
2. Manufacturer’s certificates of compliance.
3. Reservoir fabricator’s engineer letter documenting review, to be obtained after the Phase II contract has been awarded.
4. Design calculations for anode selection.
5. Field test reports.

1.06 QUALITY ASSURANCE

A. Qualifications: The cathodic protection specialist shall be experienced in the design of cathodic protection systems for at least 5 years. At least 10 of the cathodic protection specialist’s projects with comparable complexity to units provided in this section shall have been successfully used for protection of welded steel reservoirs bottoms. The Contractor shall furnish proof of the cathodic protection specialist’s qualifications within 30 days of the Final Notice to Proceed.

B. Designer: Designer shall be an NACE International certified cathodic protection specialist with a minimum of 5 years’ experience designing cathodic protections systems for the bottoms of welded steel reservoirs.

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1.07 ENVIRONMENTAL CONDITIONS

A. Cathodic protection system shall be designed to function under the following conditions:

Parameter	Value
Soil Resistivity, ohm-cm	25,000
pH	7.4 to 8.0
Chloride, mg/kg	4.2

1.08 MINIMUM REQUIREMENTS

A. Anodes:

1. Theoretical Life Expectancy: 25 years, minimum.

B. Test Stations:

1. Minimum of two test stations that include:
   a. Terminations of one No. 4 insulated reservoir connecting wire and one No. 12 insulated test wire to the reservoir.
   b. Terminations of four reference electrode leads with corrosion coupon.

C. Stationary Reference Electrodes: Four, minimum.

1.09 WARRANTY

A. The cathodic protection system shall, when maintained in operation with the manufacturer's written instructions, provide against corrosion of all submerged ferrous metal surfaces. In the event corrosion is not prevented, make whatever changes are necessary in the cathodic protection system to assure corrosion prevention.

B. Furnish installer's extended guarantee or warranty. Special guarantee shall provide for correction, or at the option of the Owner, removal and replacement of the work specified in this section found defective during a period of 2 years after the date of Owner's acceptance.

1.10 DELIVERY, STORAGE, AND HANDLING

A. Protect anodes against weather and mechanical damage. Immediately remove mechanically damaged anodes from the Site.

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PART 2 PRODUCTS

2.01 GENERAL

A. Like items of materials provided hereunder shall be the end product of one manufacturer to achieve standardization for appearance, maintenance, and replacement.

B. The impressed current cathodic protection system shall be designed to prevent corrosion on the surfaces of the floor plates in contact with foundation soil. Due to lightning protection design requirements, the tank will be electrically continuous with the rebar so the cathodic protection design shall include the surface area of the rebar within the tank support ring foundation. The general dimensions of the reservoir are shown on the Drawings. Verify actual dimensions with the Engineer prior to cathodic protection design.

2.02 IMPRESSED CURRENT SYSTEM COMPONENTS

A. Rectifiers, anodes, reference electrodes, mounting systems, and wiring shall conform to ANSI/AWWA D104 and NACE SP0388, unless otherwise noted in this Section.

1. Rectifier:
    a. Automatic potential controlled.
    b. Provide output control designed for operation with copper-copper sulfate reference electrodes.
    c. In addition to the logic circuit controls, provide physical restriction to limit current output, such as manual tap settings or an in-line dc fuse.
    d. Lightning protection for ac input and dc output.
    e. DC voltage and current meters, D’Arsonval jeweled movement type, accurate to within 2 percent of actual voltage and current output.
    f. 11-gauge, hot-dipped galvanized steel case.
2. Reference Electrodes:
    a. Provide a minimum of four reference electrodes in the tank.
    b. A minimum of one reference electrode shall be placed adjacent to an anode to monitor “over-protection”.
    c. A minimum of one reference electrode shall be placed at the furthest distance between anodes to monitor minimum potentials.
    d. The reference electrode used to control the rectifier shall be copper-copper sulfate.
    e. Provide each reference electrode with a different wire insulation color. Terminate reference electrodes on a plastic board in the rectifier.

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f. Install reference electrode wiring in separate conduits from the Dc anode supply conductors. Separate conduits as required to avoid interference with reference electrode wiring.

3. Anodes: Provide anode materials and suspension systems that will be resistant to potential icing conditions and water movement inside the tank.
4. Electrical:
   a. Electrical power shall be provided with 120-volt, single-phase, 15-ampere capacity.
   b. Provide all necessary raceways and junction boxes in accordance with Section 26 05 33, Raceways and Boxes.
   c. All wiring associated with the cathodic protection system outside the tank shall be installed in rigid galvanized steel conduit. Extend exposed rigid galvanized steel below ground a minimum of 24 inches, minimum, before transition to any non-metallic conduit.
5. Fasteners. Fasteners and metallic components of hangers used to mount cathodic protection system components, inside or outside the tank, shall be Type 316 stainless steel.

PART 3 EXECUTION

3.01 GENERAL

A. Installation of components shall conform to applicable codes and shall be consistent with best current practice in the cathodic protection industry. Coordinate installation of the cathodic protection system with other trades to ensure proper function and a neat and finished appearance following construction.

3.02 DAMAGED MATERIALS

A. Equipment of materials damaged in shipment or in the course of installation shall be replaced.

3.03 INSTALLATION

A. General: Installation of components shall conform to National Electric Code, applicable local codes, and shall be consistent with best current practice in the cathodic protection industry. Coordinate installation of the cathodic protection system with other trades to assure proper function and a neat and finished appearance following construction.

B. Damaged Materials: Equipment or materials damaged in shipment or in the course of installation shall be replaced.

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C. Electrical Power: Install electrical conductors in conduit from the electrical panel to the rectifier location, as shown on the Drawings.

D. Protective Coatings: Paint all exposed bare carbon steel cathodic protection system components as specified in Section 09 90 00, Painting and Coating.

E. Anode Lead-to-Anode Header Wire Connections: Connect the anode lead wire to the anode header wire with the specified compression connectors with the manufacturer’s recommended crimping tool.

F. Wire Splice Insulation: Insulate splices above the waterline with approved sealant.

G. Install reference electrode wires and anode wires in separate conduits.

H. Reference Electrodes:

1. Terminate two reference electrodes in each test station. Label accordingly.
2. Located two reference electrodes 5 feet from the center of the reservoir.
3. Located two reference electrodes 15 feet from the reservoir wall.
4. Locate reference electrodes 18 inches to 24 inches from ribbon anode, 4 inches below the steel floor plates.

I. Wires:

1. Protect wires form damage during placement of backfill, insulation, sand, concrete and any other Work.
2. Run wires through concrete ring wall in a galvanized steel conduit, 1-inch diameter minimum. Continue conduit to test station. Seal conduit after the wires have been installed.
3. Attach wires to test station terminals using appropriately sized ring-tongue crimp connectors.

J. Test Stations:

1. Located one test station on each side of the reservoir (180 degree separation). One test station is to be between the utility shed and reservoir’s ladder, or approved alternate location.
2. Support test stations on two unistrut channel legs per station, appropriately anchored in the soil or to the concrete ringwall. Test station shall be a minimum of 3 feet above finished grade.

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3.04 ACCEPTANCE TESTING

A. Energizing and Testing:

1. Procedure: Prior to completion of the cathodic protection system, the Contractor shall submit a detailed testing procedure for review and approval by the Engineer. The detailed testing procedure shall include, but not be limited to, functional tests of all cathodic protection system components, structure-to-environment potentials, anode current measurements, and recommended test frequencies during the first 6 months of cathodic protection system operation. Develop and submit a standard reporting form for the required information for approval by the Engineer.
2. Field Testing: When all work has been completed, a final test shall be conducted by the Contractor and witnessed by the Engineer or Owner to demonstrate that the system operates properly. The Contractor will make all necessary final adjustments in the output of the system and make sufficient tests to ensure proper installation of the cathodic protection system. Any construction defects noted by the Engineer during energizing and testing shall be located and corrected by the Contractor, at the Contractor's sole expense.

B. The Contractor shall prepare and submit two written reports summarizing the testing and including all test data. The first report shall be submitted following initial functional tests. The second report shall be submitted after the final testing and energizing of the cathodic protection system, after the 1-year coating warranty inspection and repairs. Any defects shall be corrected to the satisfaction of the Engineer and the tests repeated at no additional cost to the Owner.

3.05 OPERATION AND MAINTENANCE MANUALS

A. Develop and submit an operation and maintenance manual for the cathodic protection system for review and approval of the Engineer. Operation and maintenance manual shall include, but not be limited to, the following information:

1. General corrosion theory.
2. Cathodic protection system components.
3. Required test equipment.
4. Testing procedures and frequencies.
5. Evaluation and troubleshooting.
6. Overprotection.
7. Records and data forms.
8. Data maintenance.

3.06 ANNUAL INSPECTION AND MAINTENANCE

A. After completion of the final testing, an annual inspection and maintenance agreement proposal shall be submitted for consideration by the Owner. This inspection agreement shall provide for complete maintenance of the system on an annual basis after the correction of defects period expires.

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 31 10 00

SITE CLEARING

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:

1. Removing surface debris.
2. Removing designated paving, curbs, and other obstructions.
3. Removing designated trees, shrubs, and other plant life.
4. Removing abandoned utilities.
5. Excavating topsoil.

B. Related Sections:

1. Section 02 21 32 - Surveying
2. Section 31 22 13 - Rough Grading.

1.2 QUALITY ASSURANCE

A. Perform Work in accordance with the most recent edition of the New Mexico Standard Specifications for Public Works Construction, with latest revisions.

B. Conform to applicable State of New Mexico code for environmental requirements, disposal of debris, burning debris on site, use of herbicides.

PART 2 PRODUCTS

Not Used.

PART 3 EXECUTION

3.1 EXAMINATION

A. Section 01 00 00 - Quality Requirements: Examination of existing conditions before starting work.

B. Verify existing plant life designated to remain is tagged or identified.

C. Identify waste area and/or salvage area for placing removed materials.

3.2 PREPARATION

A. Call New Mexico “One Call” at 811 and/or local utility companies at least three (3) working days before performing Work.

1. Request that underground utilities be located and marked within and surrounding construction areas.

B. Contractor shall not work in any area where the designated work area has not been staked by Owner's Surveyor. Contractor shall be wholly liable for any damage caused by working in areas that have not been staked, or by encroaching outside the staked work area.

C. Notify Engineer at least five (5) working days prior to commencing work within 100 feet of any designated restricted area or culturally sensitive area, as shown on Plans. Do not commence work unless barricades are in place and/or archaeological monitor is present, as required. Refer to Section 01 00 00 – Basic Requirements and the Drawings for site-specific requirements.

3.3 PROTECTION

A. Locate, identify, and protect utilities indicated to remain, from damage.

B. Protect trees, plant growth, and features designated to remain, as final landscaping.

C. Protect benchmarks, survey control points, and existing structures from damage or displacement.

3.4 CLEARING

A. Clear areas required for access to site and execution of Work.

B. Remove trees and shrubs within indicated areas. Remove stumps and surface rock.

C. Clear undergrowth and deadwood, without disturbing subsoil.

D. Apply herbicide to remaining stumps to inhibit growth.

3.5 REMOVAL

A. Remove debris, rock, and extracted plant life from site, as directed in field by Engineer.

B. Tree removal:
1. Trees larger than 3” in diameter shall be cut, de-limbed, and left in stacks on edge of ROW for public firewood gatherers. Place firewood such that the public may gather it without creating safety hazards or additional disturbance to the public, work site or the environment.
2. Trees smaller than 3” in diameter, slash, and brush shall either be chipped and spread on the ROW or hauled to appropriate disposal site. Chipped material shall be distributed so as not to interfere with successful re-vegetation efforts.
3. Tree stumps and other material that cannot be chipped or used by the public shall be hauled to an appropriate disposal facility.
4. Contractor shall abide by all conditions contained in BLM pipeline and site ROW stipulations, regardless of land ownership status.

C. Partially remove paving, curbs, and other obstructions as indicated on Drawings. Neatly saw cut edges at right angle to surface.

D. Remove abandoned utilities as directed by Owner and/or Engineer. Indicate removal termination point for underground utilities on Record Documents.

E. Continuously clean up and remove waste materials from site. Do not allow materials to accumulate on site.

F. The Engineer will indicate to the Contractor which obstructions are to be removed, disposed of, or salvaged, and will require special documentation.

G. All existing fences crossed by the Work, or are within the construction area, are to be removed and rebuilt to original condition or better. Fence materials resulting from such removal are to be stored or disposed of as directed by the Engineer. Fence materials suitable for reuse or salvage that are damaged, lost or destroyed due to the Contractor's negligence or carelessness are to be replaced at the Contractor's expense.

H. Do not burn or bury materials on site. Leave site in clean condition.

3.6 TOPSOIL EXCAVATION

A. Excavate top 6 inches of topsoil from areas to be further excavated, relandscaped, or regraded, without mixing with foreign materials or vegetable matter for use in finish grading.

B. Do not excavate wet topsoil.

C. Stockpile in area designated on site to depth not exceeding 8 feet and protect from erosion. Stockpile material on impervious material and cover over with same material, until disposal.

D. Remove excess topsoil not intended for reuse, from site.

E. All equipment shall be properly maintained and with proper safety devices.

F. Contractor must maintain control of dust and minimize blowing debris.

END OF SECTION

SECTION 31 22 13

ROUGH GRADING

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:

1. Excavating subsoil.
2. Cutting, grading, filling, rough contouring, and compacting site for site structures and building pads.

B. Related Sections:

1. Section 02 21 32 – Surveying.
2. Section 31 10 00 - Site Clearing: Excavating topsoil.
3. Section 31 23 17 - Trenching: Trenching and backfilling for utilities.
4. Section 31 23 23 - Backfill: General building area backfilling.
5. Section 33 11 13 - Public Water Transmission Systems: Pipeline Right-of-Way grading.

1.2 UNIT PRICE - MEASUREMENT AND PAYMENT

A. The following payment concepts only apply when a corresponding item is included in the Bid Schedule. If no specific item is provided, then this work shall be considered incidental to any items which require grading.

B. Topsoil Fill:

1. Basis of Payment: Includes excavating existing soil, supplying soil materials, stockpiling, scarifying substrate surface, placing where required, and compacting.

C. Subsoil Fill:

1. Basis of Payment: Includes excavating existing subsoil, supplying subsoil materials, stockpiling, scarifying substrate surface, placing where required, and compacting.

D. Structural Fill:

1. Basis of Payment: Includes excavating existing subsoil, supplying structural fill materials, stockpiling, scarifying substrate surface, placing where required, and compacting.

1.3 REFERENCES

A. Subsurface data:

1. Geologic Design Data Report prepared by USBOR Four Corners Construction Office, entitled: “Navajo Gallup Water Supply Project Reach 21 Geologic Design Data Report, dated August 2015.

2. Report prepared by NV5, entitled: “Geotechnical Investigation Navajo Gallup Water Supply Project Reach 21 Regulating Tank Nos 3A & 3B”, Project No.: 444317-2360000.02, dated January 9th, 2017.

3. Note that in the event of any discrepancy or difference in requirements between the geotechnical reports referenced above and the Technical Specifications, the more stringent requirement shall apply.

4. Refer to Section 01 00 00 regarding Contractor’s ability to rely on subsurface data provided by Owner.

B. American Association of State Highway and Transportation Officials:

1. AASHTO T180 - Standard Specification for Moisture-Density Relations of Soils Using a 10-lb Rammer and an 18-in. Drop.

C. ASTM International:

1. ASTM C136 - Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.

2. ASTM D422 - Particle -Size Analysis of Soils.

3. ASTM D653 - Terminology Relating to Soil, Rock, and Contained Fluids.

4. ASTM D698 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft3 (600 kN-m/m3)).

5. ASTM D1140 - Amount of Material in Soils Finer than the No. 200 Sieve.

6. ASTM D1556 - Standard Test Method for Density of Soil in Place by the Sand-Cone Method.

7. ASTM D1633 - Test Method for Compressive Strength of Molded Soil - Cement Cylinders.

8. ASTM D2167 - Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method.

9. ASTM D2216 - Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass.

10. ASTM D2487 - Classifications of Soils for Engineering Purposes (Unified Soil Classification System).

11. ASTM D2488 - Description and Identification of Soils (Visual-Manual Procedure).

12. ASTM D2774 - Standard Practice for Underground Installation of Thermoplastic Pressure Piping.

13. ASTM D2901 - Test Method for Cement Content of Freshly Mixed Soil Cement.

14. ASTM D4253 - Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table.

15. ASTM D4254 - Minimum Index Density and Unit Weight of Sols and Calculation of Relative Density.

16. ASTM D4318 - Liquid Limit, Plastic Limit, and Plasticity Index of Soils.
17. ASTM D4564 - Density of Soil in Place by the Sleeve Method.
18. ASTM D4643 - Determination of Water (Moisture) Content of Soil by the Microwave Oven Heating.
19. ASTM D4718 - Correction of Unit Weight and Water Content for Soils Containing Oversize Particles.
20. ASTM D4832 - Compressive Strength of Controlled Low Strength Material.
21. ASTM D4914 - Density of Soil and Rock in Place by the Sand Replacement Method in a Test Pit.
22. ASTM D4959 - Determination of Water (Moisture) Content of Soil by Direct Heating.
23. ASTM D5030 - Density of Soil and Rock in Place by the Water Replacement Method in a Test Pit.
24. ASTM D5080 - Rapid Determination of Percent Compaction.
25. ASTM D6938 - Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

1.4 SUBMITTALS

A. Section 01 00 00 - Submittal Procedures.

B. Samples: Submit, in airtight containers, 20 lb sample of each type of fill to testing laboratory.

C. Materials Source: Submit name of imported materials suppliers.

D. Manufacturer's Certificate: Certify Products meet or exceed specified requirements.

1.5 CLOSEOUT SUBMITTALS

A. Project Record Documents: Accurately record actual locations of utilities remaining by horizontal dimensions, elevations or inverts, and slope gradients.

1.6 QUALITY ASSURANCE

A. Perform Work in accordance with ASTM C136, ASTM D2419, and ASTM D2434.

B. Perform Work in accordance with New Mexico Standard Specifications for Public Works Construction.

PART 2 PRODUCTS

2.1 MATERIALS

A. As specified in Section 31 23 23 - Backfill.

PART 3 EXECUTION

3.1 EXAMINATION

A. Section 01 00 00 - Quality Requirements: Examination of existing conditions before starting work.

B. Verify survey benchmark and intended elevations for the Work are as indicated on Drawings.

3.2 PREPARATION

A. Call New Mexico "One Call" at 811 and/or local utility companies at least three (3) days before performing Work.

1. Request underground utilities to be located and marked within and surrounding construction areas.

B. Notify Engineer at least five (5) working days prior to commencing work within 100 feet of any designated restricted area or culturally sensitive area, as shown on Plans. Do not commence work unless barricades are in place and/or archaeological monitor is present, as required. Refer to Section 01 00 00 and the Drawings for site-specific requirements.

C. Identify required lines, levels, contours, and datum.

D. Notify utility company to remove and relocate utilities.

E. Protect remaining utilities from damage.

F. Protect plant life, lawns, and other features remaining as portion of final landscaping.

G. Protect benchmarks, survey control point, existing structures, fences, sidewalks, paving, and curbs from excavating equipment and vehicular traffic.

3.3 SUBSOIL EXCAVATION

A. Excavate subsoil from areas to be further excavated, relandscaped, or regraded.

B. Do not excavate in rain or snow.

C. Do not excavate frozen materials.

D. Blasting is not allowed.

E. Do not excavate wet subsoil or excavate and process wet material to obtain optimum moisture content.

F. Remove excess subsoil not intended for reuse and dispose of in accordance with these Technical Specifications.

G. Benching Slopes: Horizontally bench existing slopes greater than 4:1 (H:V) to key placed fill material to slope to provide firm bearing.

1. Do not exceed maximum slope of 4:1 (H:V) unless otherwise noted on the Drawings or directed by the Engineer.

H. Stability: Replace damaged or displaced subsoil as specified for fill.

I. Notify Owner of any utility damage at once so emergency measures can be taken. The Contractor will pay for any required repairs.

J. Remove and exclude water, including storm water, groundwater, irrigation water, and/or other waters, from all excavations. Dewatering wells, well-points, sump pumps, or other means shall be used to remove water and continuously maintain groundwater at a level below the bottom of excavations. Water shall be removed and excluded until backfilling is complete and all field soils testing have been completed.

K. Excavation Below Fills and Embankments: The subgrade areas beneath embankments shall be excavated to remove not less than the top 1 foot of native material and, where such sub-grade is sloped, the native material shall be benched. After the required excavation or over-excavation has been completed, the top 12 inches of material shall be scarified and moisture added or material dried to optimum moisture and the exposed surface shall be proof rolled.

L. Excavation under areas to be paved shall extend to the bottom of the sub-base. After the required excavation has been completed, the area shall be scarified a minimum of 12 inches below the subgrade surface and recompacted prior to the placement of the sub-base aggregate and/or base course aggregate. The finished sub-grade shall be even, self-draining, and in conformance with the slope of the finished pavement. Areas that could accumulate standing water shall be regraded to provide a self-draining subgrade.

M. Damage to existing or new facilities or work caused by the Contractor's operations shall be repaired at no additional cost to the Owner.

N. Material beyond prescribed lines which is loosened by the Contractor's operations shall be removed, replaced and/or compacted, as directed by the Engineer, at no additional cost to the Owner.

3.4 FILLING

A. See Technical Specification 31 23 23 – Backfill.

3.5 DISPOSAL OF EXCAVATED MATERIALS

A. Excess excavated material or excavated material not suitable for backfill may be disposed of on-site, provided that:

1. The finished grade substantially conforms with the drawings, or any deviation therefrom is approved by the Engineer

   a. Blend with natural terrain

   b. Minimum slope: 2%

   c. Maximum slope: 4:1 (H:V)

2. All excess excavated material spread on the right-of-way is compacted to the same specifications as final backfill, as set for in Technical Specification 31 23 23 - Backfill and the Drawings

3. All on-site disposal of material is approved by the Engineer.

B. Do not dispose of waste material by dumping from tops of slopes.

C. Do not dispose of excess material within 15 feet of any wash, drainage or waterway.

D. Re-seed waste material areas in accordance with Section 32 92 19 - Seeding.

3.6 TOLERANCES

A. Section 01 00 00 - Quality Requirements: Tolerances.

B. Top Surface of Subgrade: Plus or minus 1/10 foot from required elevation.

3.7 FIELD QUALITY CONTROL

A. Section 01 00 00 - Execution Requirements: Testing, adjusting, and balancing.

B. Determine compaction characteristics of materials in accordance with ASTM D698.

C. Classify soils in accordance with ASTM D2487.

D. Field moisture content measured as specified in Section 31 23 23 - Backfill.

E. Unit weight of in-place compacted material shall be measured as specified in Section 31 23 23 - Backfill.

F. Perform in place compaction tests as specified in Section 31 23 23 - Backfill.

3.8 CORRECTION OF SUB-STANDARD WORK

A. Section 31 23 23 – Backfill: Correction of Sub-Standard Work.

END OF SECTION

SECTION 31 23 17

TRENCHING

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:

1. Excavating trenches for utilities.
2. Sheeting and shoring.
3. Disposal of excavated material.

B. Related Sections:

1. Section 02 21 32 - Surveying
2. Section 03 30 00 - Cast-in-Place Concrete.
3. Section 31 22 13 - Rough Grading: Topsoil and subsoil removal from site surface.
4. Section 31 23 18 - Rock Removal.
5. Section 31 23 23 - Backfill: General backfilling.
6. Section 33 11 13 - Public Water Transmission Systems.

1.2 REFERENCES

A. Subsurface data:

1. Geologic Design Data Report prepared by USBOR Four Corners Construction Office, entitled: "Navajo Gallup Water Supply Project Reach 21 Geologic Design Data Report, dated August 2015.
2. Report prepared by NV5, entitled: "Geotechnical Investigation Navajo Gallup Water Supply Project Reach 21 Regulating Tank Nos 3A & 3B", Project No.: 444317-2360000.02, dated January 9th, 2017.
3. Note that in the event of any discrepancy or difference in requirements between the geotechnical reports referenced above and the Technical Specifications, the more stringent requirement shall apply.
4. Refer to Section 01 00 00 regarding Contractor's ability to rely on subsurface data provided by Owner.

B. NMSSPWC

1. NMSSPWC Sections 701, 801 & 802 "Trenching, Excavation and Backfill".

C. American Association of State Highway and Transportation Officials:

1. AASHTO T180 - Standard Specification for Moisture-Density Relations of Soils Using a 10-lb Rammer and an 18-in. Drop.

D. ASTM International:

1. ASTM C136 - Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
2. ASTM D422 - Particle -Size Analysis of Soils.
3. ASTM D653 - Terminology Relating to Soil, Rock, and Contained Fluids.
4. ASTM D698 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft3 (600 kN-m/m3)).
5. ASTM D1140 - Amount of Material in Soils Finer than the No. 200 Sieve.
6. ASTM D1556 - Standard Test Method for Density of Soil in Place by the Sand-Cone Method.
7. ASTM D1633 - Test Method for Compressive Strength of Molded Soil - Cement Cylinders.
8. ASTM D2167 - Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method.
9. ASTM D2216 - Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass.
10. ASTM D2487 - Classifications of Soils for Engineering Purposes (Unified Soil Classification System).
11. ASTM D2488 - Description and Identification of Soils (Visual-Manual Procedure).
12. ASTM D2774 - Standard Practice for Underground Installation of Thermoplastic Pressure Piping.
13. ASTM D2901 - Test Method for Cement Content of Freshly Mixed Soil Cement.
14. ASTM D4253 - Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table.
15. ASTM D4254 - Minimum Index Density and Unit Weight of Sols and Calculation of Relative Density.
16. ASTM D4318 - Liquid Limit, Plastic Limit, and Plasticity Index of Soils.
17. ASTM D4564 - Density of Soil in Place by the Sleeve Method.
18. ASTM D4643 - Determination of Water (Moisture) Content of Soil by the Microwave Oven Heating.

19. ASTM D4718 - Correction of Unit Weight and Water Content for Soils Containing Oversize Particles.
20. ASTM D4832 - Compressive Strength of Controlled Low Strength Material.
21. ASTM D4914 - Density of Soil and Rock in Place by the Sand Replacement Method in a Test Pit.
22. ASTM D4959 - Determination of Water (Moisture) Content of Soil by Direct Heating.
23. ASTM D5030 - Density of Soil and Rock in Place by the Water Replacement Method in a Test Pit.
24. ASTM D5080 - Rapid Determination of Percent Compaction.
25. ASTM D6938 - Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

1.3 SUBMITTALS

A. Section 01 00 00 - Submittal Procedures: Requirements for submittals.

B. Materials Source: Submit name of imported fill materials suppliers.

C. Manufacturer's Certificate: Certify Products meet or exceed specified requirements.

1.4 QUALITY ASSURANCE

A. Perform Work in accordance with applicable New Mexico, Navajo Nation and U.S. Bureau of Reclamation standards.

B. Perform Work in accordance with applicable OSHA trench safety standards.

1.5 FIELD MEASUREMENTS

A. Verify field measurements prior to fabrication.

1.6 COORDINATION

A. Section 01 00 00 - Administrative Requirements: Coordination and project conditions.

B. Verify Work associated with lower elevation utilities is complete before placing higher elevation utilities.

PART 2 PRODUCTS

2.1 FILL MATERIALS

A. Pipe Bedding and Embedment: As specified in Section 31 23 23 - Backfill.

B. Pipe Backfill: As specified in Section 31 23 23 - Backfill.

C. Structural Fill: As specified in Section 31 23 23 - Backfill.

D. Concrete: Structural concrete, as specified in Section 03 30 00, with minimum compressive strength of 4,000 psi at 28 days. Concrete for thrust blocking with minimum compressive strength of 3,000 psi at 28 days.

PART 3 EXECUTION

3.1 PREPARATION

A. Call New Mexico "One Call" at 811 and local utilities not less than three working days before performing Work.

1. Request underground utilities to be located and marked within and surrounding construction areas.

B. Contractor shall not work in any area where the designated work area has not been staked by Owner's Surveyor. Contractor shall be wholly liable for any damage caused by working in areas that have not been staked, or by encroaching outside the staked work area.

C. Notify Engineer at least five (5) working days prior to commencing work within 100 feet of any designated restricted area or culturally sensitive area, as shown on Plans. Do not commence work unless barricades are in place and/or archaeological monitor is present, as required. Refer to Section 01 00 00 – Basic Requirements and the Drawings for site-specific requirements.

D. Identify required lines, levels, contours, and datum locations.

E. Protect plant life, lawns and other features remaining as portion of final landscaping.

F. Protect benchmarks, existing structures, fences, sidewalks, paving, and curbs from excavating equipment and vehicular traffic.

G. Maintain and protect above and below grade utilities indicated to remain.

H. Establish temporary traffic control and detours when trenching is performed in public right-of-way. Relocate controls and reroute traffic as required during progress of Work.

3.2 LINES, GRADES AND DIMENSIONS

A. Excavate trench to lines and grades indicated on Drawings.

1. Engineer reserves right to make changes in lines, grades, and depths of utilities when changes are required based on field conditions.

2. Deviations from horizontal and vertical pipe line and grade by Contractor: Refer to Section 33 11 13 – Public Water Transmission Systems.

3. When bottom of trench is rocky, over-excavate and fill as specified in Section 31 23 23 – Backfill.

B. Excavate trench to minimum width as indicated on Drawings.

1. Increase trench width as required to meet required clearances between pipe and trench wall, to avoid voids in the haunch areas of the pipe and to meet embedment compaction requirements or minimum soil cement slurry layer thickness. Increased trench width, if needed to meet these requirements, shall be provided at no additional cost to the Owner.

2. Contractor is advised that the trench widths shown in the Drawings are minimum widths only. In the event that the Contractor is unable to meet pipe embedment and compaction specifications using the minimum trench width and needs to

increase trench width in order to meet these specifications, such increase in trench width shall be provided at no additional cost to the Owner.

3.3 TRENCHING

A. Excavate subsoil required for utilities.

B. Remove to 6 inches of topsoil and stockpile separately. The stockpiled soil shall be free of organic material. This topsoil shall be spread on top of the reclaimed area after backfilling, prior to re-seeding.

C. Remove lumped subsoil, boulders, and rock to bottom of trench.

D. Rock removal requiring specialized equipment or procedures as defined in Section 31 23 18 - Rock Removal, will be identified, quantified and paid for in accordance with Section 31 23 18.

E. Allowable open trench: Trenches may be opened in advance of pipe placement and backfill operations under the following conditions:

1. Do not open more than ½ mile of trench at one time. Do not leave any section of trench open for more than 24 hours.

2. Do not leave any trench open at the end of the workday within 100 feet of any road, driveway parking lot or other trafficked area, whether said road or driveway is shown on the Drawings or not.

3. Do not block vehicular traffic or impede access to homes or businesses.

4. Temporary fences shall be required for all trenches left open when the Contractor is not working on-site. Temporary fencing methods and materials shall be subject to approval by the Bureau of Land Management and the Engineer. All required temporary fencing shall be provided at no additional cost to the Owner.

5. Provide security at open trenches to protect the public, livestock, wildlife and the environment.

a. Comply with all stipulations set forth by the Bureau of Land Management, San Juan County, BIA Department of Transportation, the Navajo Nation, and other land-controlling agencies and owners of existing utility lines. These stipulations are provided Appendices C, D, and E.

b. Provide animal escape ramps and cross-overs in accordance with the BLM pipeline ROW stipulations provided in Appendix C.

6. Contractor is solely responsible for safety of all open trenches and bears sole liability for any incidents or accidents arising from open trenches.

7. The Owner may further restrict the amount of open trench as needed due to safety, land use or environmental considerations.

F. Remove water or materials that interfere with Work. Remove groundwater by pumping to keep excavations dry.

G. Provide uniform and continuous bearing and support for bedding material and pipe.

H. Do not interfere with 45 degree bearing splay of foundations. Any excavation in this area shall be backfilled and compacted using the same materials and methods as structural fill for new buildings. Refer to Section 31 23 23.

I. Slope or shore trench as needed to meet safety requirements. When sidewalls cannot be sloped, provide sheeting and shoring to protect excavation as specified in this section.

J. When subsurface materials at bottom of trench are loose or soft, excavate to greater depth as directed by Engineer until suitable material is encountered. Backfill and compact to reach specified or directed line and grade. Refer to specifications for overexcavation backfill, as set forth in Section 31 23 23.

K. Cut out soft areas of subgrade not capable of compaction in place. Backfill and compact to specified or directed line and grade. Refer to specifications for overexcavation backfill, as set forth in Section 31 23 23.

L. Trim excavation. Hand trim for bell and spigot pipe joints. Remove loose matter.

M. Correct over excavated areas with compacted backfill as specified for authorized excavation or replace with fill concrete as directed by Engineer.

N. Remove excess subsoil not intended for reuse from site.

O. Do not excavate in the rain or snow without approval from the Engineer.

P. Do not excavate in frozen materials without approval from the Engineer.

Q. Blasting is not allowed.

3.4 ADDITIONAL EXCAVATION

A. Perform additional excavation in trench bottom for pipe foundations as show on drawings and other additional excavations beyond specified lines as directed by the Engineer.

3.5 OVEREXCAVATION

A. When foundation material is over-excavated beyond specified or directed lines, fill the over-excavation with embedment or bedding material and compact in accordance with Section 31 23 23 - Backfill.

B. If foundation material is over-excavated by being disturbed or loosened during excavation, compact material in place or remove and replace with embedment or bedding material as determined by the Engineer and compact in accordance with Section 31 23 23 - Backfill.

3.6 SHEETING AND SHORING

A. Sheet, shore, and brace excavations to prevent danger to persons, structures and adjacent properties and to prevent caving, erosion, and loss of surrounding subsoil.

B. Support trenches more than 5 feet deep excavated through unstable, loose, or soft material. Provide sheeting, shoring, bracing, or other protection to maintain stability of excavation.

C. Design sheeting and shoring to be removed at completion of excavation work. If the Engineer orders the sheeting to be left in place for the protection of the work, a payment will be allowed only for the actual cost of the timber left in place.

D. Repair damage caused by failure of the sheeting, shoring, or bracing and for settlement of filled excavations or adjacent soil.

E. Repair damage to new and existing Work from settlement, water or earth pressure or other causes resulting from inadequate sheeting, shoring, or bracing.

3.7 BACKFILLING OF TRENCHES

A. See Section 31 23 23 – Backfill for general backfill requirements, as well as trench backfill, bedding and embedment requirements around pipelines.

3.8 DISPOSAL OF EXCAVATED MATERIALS

A. Excess excavated material or excavated material not suitable for backfill may be disposed of on-site, provided that:

1. The finished grade substantially conforms with the drawings, or any deviation therefrom is approved by the Engineer

   a. Blend with natural terrain

   b. Minimum slope: 2%

   c. Maximum slope: 4:1, unless otherwise noted on Drawings

2. All excess excavated material spread on the right-of-way is compacted to the same specifications as final backfill, as set forth in Section 31 23 23 - Backfill and the Drawings, and

3. All on-site disposal of material is approved by the Engineer.

B. Do not dispose of waste material by dumping from tops of slopes.

C. Do not dispose of excess material within 15 feet of any wash, drainage or waterway.

D. Re-seed waste material areas in accordance with Section 32 92 19 - Seeding.

3.9 TOLERANCES

A. Section 01 00 00 - Quality Requirements: Tolerances.

B. Top Surface of Backfilling Under Paved Areas: Plus or minus 1 inch from required elevations.

3.10 FIELD QUALITY CONTROL

A. Section 01 00 00 - Execution Requirements: Testing, adjusting, and balancing.

B. Determine compaction characteristics of materials in accordance with ASTM D698.

C. Classify soils in accordance with ASTM D2487.

D. Field moisture content measured as specified in Section 31 23 23 - Backfill.

E. Unit weight of in-place compacted material shall be measured as specified in Section 31 23 23 - Backfill.

F. Perform in place compaction tests as specified in Section 31 23 23 - Backfill.

G. When tests indicate Work does not meet specified requirements, remove Work, replace, compact, and retest at no additional cost to the Owner.

3.11 PROTECTION OF FINISHED WORK

A. Section 01 00 00 - Execution Requirements: Protecting installed construction.

B. Reshape and re-compact fills subjected to vehicular traffic during construction.

END OF SECTION

SECTION 31 23 18

ROCK REMOVAL

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:

1. Removing identified and discovered rock during excavation.

B. Related Sections:

1. Section 31 23 17 - Trenching: Trenching and backfilling for utilities.
2. Section 31 23 23 - Backfill: Backfill materials.

1.2 REFERENCES

A. Subsurface data:

1. Geologic Design Data Report prepared by USBOR Four Corners Construction Office, entitled: “Navajo Gallup Water Supply Project Reach 21 Geologic Design Data Report, dated August 2015.
2. Report prepared by NV5, entitled: “Geotechnical Investigation Navajo Gallup Water Supply Project Reach 21 Regulating Tank Nos 3A & 3B”, Project No.: 444317-2360000.02, dated January 9th, 2017.
3. Note that in the event of any discrepancy or difference in requirements between the geotechnical reports referenced above and the Technical Specifications, the more stringent requirement shall apply.
4. Refer to Section 01 00 00 regarding Contractor’s ability to rely on subsurface data provided by Owner.

1.3 UNIT PRICE - MEASUREMENT AND PAYMENT

A. Trench Rock Removal:

1. Basis of Measurement:
   a. By vertical linear foot (VLF) of trench excavation. Each VLF is measured as horizontal linear foot of trench multiplied by the depth of excavated rock. The depth of the excavated rock may be less than the total trench depth. The width of trench is not a factor in the VLF calculation.
2. Basis of Payment:
   a. Includes preparation of rock for removal, mechanical disintegration of rock, removal from position, loading and removing from trench.
   b. Payment will not be made for over-excavated work beyond the required bedding depth below invert elevation of pipe as shown on Drawings, nor for replacement materials.

c. If native trench rock is processed and used as pipe bedding or backfill material, the cost of such processing will be considered incidental to the cost of trench rock removal.

d. If trench rock is hauled away from site and replaced with imported material, the costs of rock hauling and disposal, as well as the costs of obtaining and hauling imported fill material will be considered incidental to the cost of trench rock removal.

e. The cost of placing and compacting embedment and backfill material, regardless of whether it is native or imported, will be considered incidental to pipeline installation.

3. Contractor shall notify Engineer prior to commencement of rock removal work when rock is encountered and specialized equipment will be required, and await approval from Engineer before proceeding.

4. Contractor and Engineer must agree on rock quantity at the end of each day that such work was completed, and both parties must sign off on the quantity on the corresponding Engineer's daily field report.

5. Pot holing data is included in Exhibit B to the Contract Documents package. This data is provided for informational purposes only and will not be used as a basis for payment. Final quantities will be determined in the field during the construction process, in coordination with the Engineer.

1.4 DEFINITIONS

A. Rock: Solid mineral material of size that cannot be removed with conventional equipment such as a track excavator or chain-driven trencher (excluding rock saw).

B. For trench excavation, a 235C Caterpillar excavator with a medium stick and a rock ripping bucket, or equivalent equipment, is considered conventional equipment, if it can excavate at a production rate of at least 30 bank cubic yards per hour.

C. If material cannot be excavated by conventional equipment, the Engineer must be immediately notified. The Contractor shall provide performance tests of the specified conventional or equivalent equipment. If the Engineer confirms in writing that the specified conventional equipment cannot perform at the production rates specified, the excavation shall be considered rock excavation.

1.5 SUBMITTALS

A. Submit type of equipment to be used for rock removal and/or processing.

B. If processed native rock is to be used for embedment and backfill, submit sieve analyses and other geotechnical data on the processed material, as required in field by Engineer.

1. Laboratory costs associated with such testing shall be reimbursable under project testing allowance. Other costs, such as sample collection and transport, are not covered under the allowance.

1.6 SCHEDULING

A. Section 01 00 00 - Administrative Requirements: Coordination.

PART 2 PRODUCTS

Not used.

PART 3 EXECUTION

3.1 EXAMINATION

A. Section 01 00 00 - Administrative Requirements: Coordination.

B. Verify site conditions and note subsurface irregularities affecting Work of this section.

3.2 PREPARATION

A. Identify required lines, levels, contours, and datum.

3.3 ROCK REMOVAL BY MECHANICAL METHOD

A. Excavate and remove rock by mechanical methods.

B. Cut away rock at bottom of excavation to form level bearing.

C. Remove shaled layers to provide sound and unshattered base for footings.

D. For utility trenches, excavate to below invert elevation of pipe as shown on Drawings to ensure adequate bedding below pipe, and provide trench width as shown on Drawings to allow for proper embedment compaction or soil cement placement on sides of pipe. Exceptions to minimum trench width will be considered by Engineer if Contractor can demonstrate proper bedding and compaction are provided.

E. Disposal of excavated materials: Removed materials may be disposed of on-site, provided all criteria under Section 31 23 17 – Trenching, Article 3.8, are met.

3.4 ROCK REMOVAL BY EXPLOSIVE METHODS

A. Not allowed.

3.5 FIELD QUALITY CONTROL

A. Section 01 00 00 - Execution Requirements: Testing, adjusting, and balancing.

B. Request visual inspection of foundation bearing surfaces by Engineer before installing subsequent work.

END OF SECTION

SECTION 31 23 23

BACKFILL

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:

1. Backfilling building perimeter to subgrade elevations.
2. Backfilling site structures to subgrade elevations.
3. Fill under slabs-on-grade.
4. Fill under paving.
5. Fill for over-excavation.
6. Pipe bedding material.

B. Related Sections:

1. Section 02 21 32 - Surveying
2. Section 03 30 00 - Cast-in-Place Concrete: Concrete materials.
3. Section 31 22 13 - Rough Grading: Site filling.
4. Section 31 23 17 - Trenching: Backfilling of utility trenches.
5. Section 31 23 18 - Rock Removal.
6. Section 31 23 25 - Soil Cement Slurry.
7. Section 33 11 13 - Public Water Transmission Systems.

1.2 REFERENCES

A. Subsurface data:

1. Geologic Design Data Report prepared by USBOR Four Corners Construction Office, entitled: “Navajo Gallup Water Supply Project Reach 21 Geologic Design Data Report, dated August 2015.
2. Report prepared by NV5, entitled: “Geotechnical Investigation Navajo Gallup Water Supply Project Reach 21 Regulating Tank Nos 3A & 3B”, Project No.: 444317-2360000.02, dated January 9th, 2017.
3. Note that in the event of any discrepancy or difference in requirements between the geotechnical reports referenced above and the Technical Specifications, the more stringent requirement shall apply.
4. Refer to Section 01 00 00 regarding Contractor’s ability to rely on subsurface data provided by Owner.

B. American Association of State Highway and Transportation Officials:

1. AASHTO T180 - Standard Specification for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop.

C. ASTM International:

1. ASTM C136 - Standard Test Method for Sieve Analysis of Fine and Coarse ‘‘Aggregates.
2. ASTM D422 - Particle -Size Analysis of Soils.
3. ASTM D653 - Terminology Relating to Soil, Rock, and Contained Fluids.
4. ASTM D698 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft3 (600 kN-m/m3)).
5. ASTM D1140 - Amount of Material in Soils Finer than the No. 200 Sieve.
6. ASTM D1556 - Standard Test Method for Density of Soil in Place by the Sand-Cone Method.
7. ASTM D1633 - Test Method for Compressive Strength of Molded Soil - Cement Cylinders.
8. ASTM D2167 - Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method.
9. ASTM D2216 - Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass.
10. ASTM D2487 - Classifications of Soils for Engineering Purposes (Unified Soil Classification System).
11. ASTM D2488 - Description and Identification of Soils (Visual-Manual Procedure).
12. ASTM D2774 - Standard Practice for Underground Installation of Thermoplastic Pressure Piping.
13. ASTM D2901 - Test Method for Cement Content of Freshly Mixed Soil Cement.
14. ASTM D4253 - Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table.
15. ASTM D4254 - Minimum Index Density and Unit Weight of Sols and Calculation of Relative Density.
16. ASTM D4318 - Liquid Limit, Plastic Limit, and Plasticity Index of Soils.
17. ASTM D4564 - Density of Soil in Place by the Sleeve Method.
18. ASTM D4643 - Determination of Water (Moisture) Content of Soil by the Microwave Oven Heating.
19. ASTM D4718 - Correction of Unit Weight and Water Content for Soils Containing Oversize Particles.
20. ASTM D4832 - Compressive Strength of Controlled Low Strength Material.
21. ASTM D4914 - Density of Soil and Rock in Place by the Sand Replacement Method in a Test Pit.

22. ASTM D4959 - Determination of Water (Moisture) Content of Soil by Direct Heating.
23. ASTM D5030 - Density of Soil and Rock in Place by the Water Replacement Method in a Test Pit.
24. ASTM D5080 - Rapid Determination of Percent Compaction.
25. ASTM D6938 - Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

D. Bureau of Reclamation (USBR):

1. USBR EM - Earth Manual, Part 2, Third Edition (1990).
2. Procedure No. and Title:
    a. USBR EM 3900 - Standard Definitions of Terms and Symbols Relating to Soil Mechanics .
    b. USBR EM 5000 - Determining Unified Soil Classification (Laboratory Method).
    c. USBR EM 5005 - Determining Unified Soil Classification (Visual Method).
    d. USBR EM 5300 - Determining Moisture Content of Soil and Rock by the Oven Method.
    e. USBR EM 5315 - Determining Moisture Content by the Microwave Method.
    f. USBR EM 5325 - Performing Gradation Analysis of Gravel Size Fraction of Soils.
    g. USBR EM 5330 - Performing Gradation Analysis of Fines and Sand Size Fraction of Soils, Including Hydrometer Analysis.
    h. USBR EM 5335 - Performing Gradation Analysis of Soils Without Hydrometer.
    i. USBR EM 5350 - Determining the Liquid Limit of Soils by the One Point Method.
    j. USBR EM 5355 - Determining the Liquid Limit of Soils by the Three Point Method.
    k. USBR EM 5360 - Determining the Plastic Limit and Plasticity Index of Soils.
    l. USBR EM 5500 - Performing Laboratory Compaction of Soils - 5.5 lb Rammer and 18-in Drop.
    m. USBR EM 5525 - Determining the Minimum Index Unit Weight of Cohesionless Soils.
    n. USBR EM 5530 - Determining the Maximum Index Unit Weight of Cohesionless Soils.

o. USBR EM 5605 - Determining the Permeability and Settlement of Soils Containing Gravel.

p. USBR EM 7205 - Determining Unit Weight of Soils In-Place by the Sand-Cone Method.

q. USBR EM 7215 - Determining Unit Weight of Soils In-Place by the Sleeve Method.

r. USBR EM 7220 - Determining Unit Weight of Soils In-Place by the Sand Replacement Method in a Test Pit.

s. USBR EM 7221 - Determining Unit Weight of Soils In-Place by the Water Replacement Method in a Test Pit.

t. USBR EM 7230 - Determining Unit Weight and Moisture Content of Soils In-Place - Nuclear Moisture - Density Gauge.

u. USBR EM 7240 - Performing Rapid Method of Construction Control.

v. USBR EM 7250 - Determination of Percent Relative Density.

w. USBR EM 7255 - Determining the Percent Compaction of Earthwork for Construction Control.

1.3 DEFINITIONS

A. Percentage Compaction – Ratio, expressed as percentage, of actual density of material compared with maximum dry density based on Standard Proctor (ASTM D698).

B. Optimum Moisture Content – Based on Standard Proctor (ASTM D698).

C. Unified Soil Classification System – Based on ASTM D2487.

1.4 SUBMITTALS

A. Section 01 00 00 - Submittal Procedures.

B. Submit samples and certified test documentation of all materials to be used.

C. Materials Source: Submit name of imported fill materials suppliers.

D. Manufacturer's Certificate: Certify Products meet or exceed specified requirements.

E. Submit field soil test on material in place as backfill.

PART 2 PRODUCTS

2.1 NATIVE FILL MATERIAL

A. Native material may be used for bedding, embedment and/or backfill, provided that said material meets all specifications set forth in this section. The Contractor may screen or otherwise process the material on-site to meet the specifications.

B. No dedicated borrow area for fill material has been pre-determined for this project. Native material may be borrowed from within the designated right-of-way and hauled within the project area if needed, provided that

a. All borrow areas receive prior approval from the Engineer. Finished grades shall conform to the finished grades shown in the plans, or any deviations therefrom must receive prior approval by the Engineer.

b. Borrow areas do not encroach beyond the designated project right-of-way. Borrow areas shall not encroach on any protected culturally sensitive area.

c. All borrow areas are sloped and dressed to minimize erosion.

d. Adequate stormwater pollution prevention measures are installed and maintained during construction. Such controls must be approved by the Engineer.

e. All borrow areas are re-seeded upon completion of the project, in accordance with Technical Specification 32 92 19, and post-construction stormwater controls are installed with approval from the Engineer.

C. All costs incurred in removing, hauling or processing native material and reclaiming borrow sites shall be considered incidental and shall be borne by the Contractor at no additional expense to the Owner.

D. The Owner makes no guarantee that native materials meeting the fill and backfill material specifications contained herein are available within the project area.

2.2 IMPORTED FILL MATERIAL

A. If imported materials are required to meet the quantity requirements of the project, it will be provided at no additional expense to the Owner.

B. If imported materials are required to backfill trenches where rock has been removed and disposed of, the cost of the imported fill material shall be included in the Contractor's bid price for rock excavation and backfill. Refer to Section 31 23 18 – Rock Removal.

2.3 TYPES OF ACCEPTABLE FILL MATERIAL

A. Structural Fill: Structural fill for use as sub-foundation material under tanks, buildings and other structures shall be provided in accordance with the Geotechnical Report provided in Exhibit A of the Contract Documents.

B. Fill for Appurtenances: Fill under and around in-line valves and structures at the same elevation as the pipe shall comply with specifications for the corresponding type of fill under or around the pipe. Fill under and around appurtenances such as valves, vaults and other structures above the top of the pipe shall comply with specifications for initial backfill material.

C. Pipe Bedding and Embedment Material: The following types of material are acceptable for use as pipe bedding and embedment material:

1. Crushed Rock: Not more that 25% passing 3/8-inch sieve and not more than 12% fines. Maximum particle size shall not exceed ½ inch for pipe bedding and ¾ inch for embedment.

2. Clean Coarse-Grained Soils: Sands and gravels with 12% or less fines. Unified Soil Classification System designation GW, GP, SW, SP or any soil beginning

with one of these symbols. Maximum particle size shall not exceed ½ inch for pipe bedding and ¾ inch for embedment.

3. Coarse-Grained Soils with Fines: Sands and gravels with more than 12% fines. Unified Soil Classification System designation GC, GM, SC, SM or any soil beginning with one of these symbols. Maximum particle size shall not exceed ½ inch for pipe bedding and ¾ inch for embedment.

4. Sandy or Gravelly Fine-Grained Soils: Fine-grained soils (LL<50) with medium to no plasticity and with 30% or more coarse-grained particles. Unified Soil Classification System designation CL, ML or CL-ML. Maximum particle size shall not exceed ½ inch for pipe bedding and ¾ inch for embedment.

5. Other: Other types of material may be considered only with prior written approval by the Engineer. The Contractor is advised that soil amendment and/or higher levels of compaction may be required if using other soil types. Any costs associated with use of other soil types shall be borne by the Contractor at no additional expense to the Owner.

D. Pipe Backfill Material:

1. Initial backfill: All material placed in the trench between the top of the embedment and 18 inches above the top of the pipe shall be free from clumps, organic material, frozen material, debris or rocks larger than ¾ inch.

2. Final backfill: All material placed in the trench more than 18 inches above the top of the pipe shall be free from clumps, organic material, frozen material, debris or rocks larger than 3 inches.

E. Drainage Culvert Backfill Material:

1. All material placed in the trench for galvanized drainage culvert pipe bedding and backfill shall be acceptable fill material as listed previously, with the following additional requirements:

a. Resistivity (as per AASHTO T 288) greater than 2000 ohm-cm.

b. pH (as per AASHTO T289) greater than 6.0.

c. Volcanic ash type material for backfill shall not be used.

F. Base Course: Refer to Technical Specification 32 11 23 – Aggregate Base Course and Gravel.

G. Soil Cement Slurry: Refer to Technical Specification 31 23 25 – Soil Cement Slurry.

H. All fill material shall be free of clumps, organic material, frozen material, ice, snow, debris or organic contaminants.

PART 3 EXECUTION

3.1 EXAMINATION

A. Section 01 00 00 - Administrative Requirements: Coordination and project conditions.

B. Verify subdrainage, dampproofing, or waterproofing installation has been inspected.

C. Verify structural ability of unsupported walls to support loads imposed by fill.

3.2 PREPARATION

A. Compact subgrade to density requirements for subsequent backfill materials.

B. Cut out soft areas of subgrade not capable of compaction in place. Backfill with structural fill and compact to density equal to or greater than requirements for subsequent fill material.

C. Scarify subgrade surface to depth of 8 inches.

D. Proof roll to identify soft spots; fill and compact to density equal to or greater than requirements for subsequent fill material.

3.3 USE OF ACCEPTABLE MATERIALS

Fill and Backfill materials specified in Part 2 of this Section shall be used in accordance with the following provisions:

A. Over-excavation: Backfill to specified or directed lines using Embedment or Bedding material as specified above.

B. Bedding: Use Bedding material as specified above.

C. Embedment: Use embedment material as specified above.

D. Initial backfill: For backfilling between top of embedment (0.7 of pipe O.D.) and 18 inches above top of pipe, use initial backfill material as specified above.

E. Final backfill: For backfilling more than 18” above top of pipe, backfill as follows:

1. Outside of surfaced roads, driveways or parking areas: Use final backfill material as specified above.

2. Under surfaced or paved roads, driveways or parking areas: Use final backfill material as specified above, topped with base course as specified above. Apply base course to same thickness as existing driving surface, or 6 inches, whichever is greater. If paved, apply pavement patch to thickness equal to or greater than existing pavement.

F. Embankments: Use final backfill material as specified above, unless otherwise indicated on the Drawings.

G. Under buildings, tanks, slabs-on-grade and other structures: Use structural fill as specified above unless otherwise indicated on Drawings.

H. Soil Cement Slurry: At Contractor’s option and expense, soil cement slurry may be used in lieu of bedding, embedment, initial backfill and/or final backfill materials. Soil cement slurry, if used, shall be provided at no additional expense to the Owner, and conforming to Section 31 23 25 Soil Cement Slurry.

3.4 BACKFILLING FOR STRUCTURES, SITE WORK AND APPURTENANCES

A. Refer to the Geotechnical Report in Exhibit A regarding any issues not specifically addressed in these Technical Specifications. In the event of any discrepancies or differences in requirements between the Geotechnical Report and the Technical Specifications, the more stringent requirement shall apply.

B. Backfill areas to lines and grades as indicated on the Drawings or as directed by the Engineer.

1. For demolition work, backfill to existing grade or finished grade as indicated on Drawings, or as directed by the Engineer.

C. Systematically backfill to allow maximum time for natural settlement.

D. Do not backfill over porous, wet or spongy subgrade surfaces. Do not place backfill if either the material or the surface on which it is to be placed is frozen.

E. Each layer shall be thoroughly mixed as necessary to promote uniformity of material in each layer.

F. Place material in continuous, uniform layers such that all spaces around rocks and clods are filled. Thickness of such layers shall be as follows:

1. Subsoil Fill: Maximum 8 inches compacted depth.

2. Structural Fill: Maximum 6 inches compacted depth.

3. Granular Fill: Maximum 6 inches compacted depth.

G. Employ placement method that does not disturb or damage other work.

H. Slope grade away from building minimum 4%, unless otherwise noted on the Drawings.

I. Make gradual grade changes. Blend slope into level areas.

J. Shape and drain embankments and excavations, maintain ditches and drains to provide drainage at all times. Protect graded areas against action of elements prior to acceptance of work, and reestablish grade where settlement or erosion occurs.

K. Bench hillside slopes or fills to key the embankment. Remove and re-compact a minimum of 12 inches normal to the slope of the hillside or fill as the embankment or fill is brought up in layers.

L. Spread stockpiled topsoil on areas to be reclaimed prior to re-seeding.

M. Remove surplus backfill materials from site in accordance with Technical Specification 31 22 13 – Rough Grading.

N. Leave fill material stockpile areas free of excess fill materials.

3.5 BACKFILLING OF TRENCHES

A. Place material in pipe trenches to lines and grades indicated on Drawings or as directed by Engineer.

B. Do not place material when either the material or the surface upon which it is to be placed upon are frozen.

C. When using select material for pipe bedding, place bedding material below bottom of pipe before pipe is laid. Grade bedding material parallel to bottom of pipe.

D. When using select material for pipe embedment:

1. Exercise care not to damage pipe or appurtenances when placing embedment material.

2. Ensure material is placed to equal height on both sides of pipe to avoid unequal loading and possible lateral displacement of the pipe. Elevation difference of embedment between each side of pipe shall not exceed 6 inches.

3. Place material in uniform layers.

4. Work material into pipe haunches to prevent voids and achieve specified compaction under the haunches.

E. When using soil cement slurry: See Technical Specification 31 23 25 – Soil Cement Slurry.

F. If pipe laying operations are interrupted for more than 24 hours, cover pipe laid in the trench with backfill.

G. When the bottom of the trench is rocky, the trench shall be overexcavated and backfilled by 4 inches prior to placing the bedding layer, as directed by the Engineer. Backfill of this overexcavation shall comply with the requirements for overexcavation backfill provided in these Technical Specifications.

H. When using crushed rock or gravel for embedment on stretches longer than 300 feet, install trench plugs composed on silty, non-plastic material at 300 feet intervals to prevent piping of trench water through the embedment.

3.6 COMPACTION

A. Do not place and compact soil under the following conditions:

1. Ambient air temperature below freezing

2. Rain that creates puddles in clayey or silty materials

3. Ice or snow pockets visible in material being placed.

B. Surface Preparation:

1. Prepare surface so that first compacted lift will be placed on firm, stable base. Compact surface to specified percent compaction, if necessary.

2. For water-retaining compacted fill, scarify and moisten surface to provide satisfactory bonding surface before placing first layer of material to be compacted.

3. Do not place material to be compacted on frozen surface.

C. Compact material in trenches in layers having approximately the same top elevation on both sides of the pipeline to avoid unequal loading and displacement of the pipe.

D. Placement:

1. Place soil to be compacted in horizontal layers.

2. Blend materials as needed to ensure compacted fill is homogenous and free from lenses, pockets, streaks, voids, laminations and other imperfections.

E. Compaction Procedures:

1. Silty or Clayey Material:

a. Compact with mechanical impact tampers, tamping rollers, vibrating pad foot rollers, rubber tire rollers or other suitable compaction equipment.

b. Uniformly distribute equipment passes.

c. Compact in horizontal layers to compacted thickness of 6 inches or less.

2. Cohesionless Free-Draining Material: Compact in horizontal layers to maximum compacted thickness of:

a. Tampers and rollers: 6 inches

b. Crawler-type tractors, vibrating drum rollers, surface vibrators or similar equipment: 12 inches

c. Saturation and internal vibration: Penetrating depth of vibrator.

3. When compacting pipe embedment material, exercise care not to damage the pipe or appurtenances with compaction equipment. Do not apply compaction equipment directly above the pipe.

4. Demonstration: Lift thicknesses may vary depending on equipment and methods. Field adjustments to the specified lift thicknesses may be allowed or required. Contractor shall demonstrate that proposed equipment and methods will meet required compaction for the proposed lift thickness.

5. Flooding and jetting is not allowed unless specifically approved by the Engineer.

F. Moisture Content:

1. Optimum moisture content for each soil type, whether native soil or imported material, shall be determined by the Standard Proctor method, ASTM D 698.

2. Moisture content during compaction shall be no more than 2 percentage points wet or dry of optimum moisture content.

3. Moisten or aerate material, as necessary, to provide specified moisture content. Add water to soil in increments that will permit moisture content to be uniform and homogenous through each layer after mixing.

4. Add no more than 2 percent water to fill by sprinkling just prior to compaction when fill is clayey and contains dry clods of clay.
   a. If clayey soil is more than 2 percent below optimum moisture, pre-conditioning and curing may be required to obtain uniform and homogenous distribution of moisture in clods.
   b. Use of disks, harrows or rakes may be required to blend moisture prior to placement and compaction.
5. For cohesionless soils, add water as necessary during compaction, as these soils are free-draining.

G. Minimum Percent Compaction:

1. Contractor is advised that compaction requirements shall be strictly enforced. In the event that the contractor is unable to meet compaction requirements for pipe embedment using select material, the Contractor shall have the option to use soil cement at no additional cost to the Owner.
2. Over-excavation – Backfill of overexcavation to specified or directed lines shall be compacted to same percent compaction as embedment material or undisturbed foundation material, whichever is greater. If the in-place compaction of the undisturbed foundation material is greater than 95%, the overexcavation backfill may be compacted to 95%.
3. Embedment – Compact pipe embedment material to percent compaction as indicated on Drawings for given soil classification, pipe wall thickness diameter ratio (DR) and depth of cover. For trenches within driving surfaces of roads, driveways or parking areas (both paved and unpaved), compact to 95%.
4. Initial and Final Backfill
   a. Compact backfill to 95% for trenches within:
      1) The driving surfaces or prisms of roads, driveways or parking areas (both paved and unpaved), within wash or gas line crossings, crossings under bar ditches, and crossings at “head cutting” areas.
      2) Around valve boxes, air valve vaults, flush valves and vault foundations.
      3) Against thrust blocks and horizontal and vertical ells.
   b. For trenches outside of roads, driveways, parking areas, gas line crossing, or wash crossings, compaction of the backfill is not required, provided soil is mounded above the trench.
5. Embankments – Compact to same requirements as Final Backfill.
6. Under tanks, slabs and other structures – Compact in accordance with Geotechnical reports.
7. Tank site – Compact all driving surfaces and fill slopes to 95%.
8. Note that all Percent Compaction values in these Technical Specifications and Drawings are based on Standard Proctor, ASTM D698.

H. Soil Cement Slurry may be used in trenches, at Contractor's option and expense, to replace bedding, embedment or backfill materials where it is not practical to reach minimum compaction requirements using select material.

1. If soil cement slurry is to be used in lieu of embedment material, soil cement slurry shall also replace the bedding material. Do not use soil cement slurry for embedment on top of select material bedding.

3.7 TOLERANCES

A. Section 01 00 00 - Quality Requirements: Tolerances.

B. Top Surface of Backfilling within Building Areas: Plus or minus 1 inch from required elevations.

C. Top Surface of Backfilling under Paved Areas: Plus or minus 1 inch from required elevations.

D. Percent Compaction: Shall meet minimum required compaction as set forth in these Technical Specifications

E. Moisture Content: As set forth in these Technical Specifications.

3.8 FIELD QUALITY CONTROL

A. Section 01 00 00 - Execution Requirements: Testing, Adjusting, and Balancing.

B. Classification of materials to determine adequacy for use as fill or backfill shall be performed in accordance with ASTM D2487 and designated based on the Unified Soil Classification System described therein.

C. Measurement of optimum moisture content and maximum dry density for each type of material to be compacted shall be determined using the Standard Proctor method, ASTM D698.

1. All references to "optimum moisture content" or "percent compaction" in these Technical Specifications and on the Drawings are based on Standard Proctor, ASTM D698.

2. While it may not be necessary to perform a separate Proctor test for every single compaction test location, it is necessary to perform this test for every type of material to be field tested. All material tested for compaction must correspond to a representative Proctor test.

3. The Contract Documents contains the geotechnical report which includes in-situ soil moisture measurements and Standard Proctor test results (including optimal moisture content) from test holes at various locations along the pipeline. Contractor is advised that test holes reveal information about only a very small area, and sub-surface conditions between the test holes may vary. Contractor is wholly responsible for any assumptions made about sub-surface conditions between the test holes. Moreover, in-situ moisture content varies with time, and the Owner makes no representation that the in-situ moisture at the time the measurements were taken will be the same at the time of construction.

a. Contractor shall perform Proctor tests on actual fill material (whether native or imported) and shall base determination of optimum moisture content and maximum density for compaction on the Contractor's own tests.

4. Proctor tests upon which the Contractor bases determination of optimum moisture content and maximum density for calculation of percent compaction are subject to approval by the Engineer. The Engineer may require additional tests to ensure that Proctor tests are representative of the actual fill material being compacted.

D. Field moisture content shall be measured by one or more of the following methods, as determined by the Engineer:

1. ASTM D2216 (USBR EM 5300)

2. ASTM D6938 (USBR EM 7230), provided that corrections can be made of gage error for the specific soils tested. The moisture content of the total material may require adjustment for the control fraction in accordance with ASTM D4718 (USBR EM 7230, Method C).

3. ASTM D4959 or ASTM D4643 (USBR EM 5315), provided that the results have been correlated to ASTM D 2216 (USBR EM 5300) for the specific soil tested.

4. For silty or clayey soils containing more than 5% gravel: Results of water content corrected for oversized particle in accordance with ASTM D4718.

E. Unit weight of in-place compacted material shall be measured as follows:

1. Haunch area of pipe – By Drive Cylinder (ASTM D2937) or by Sand Cone (ASTM D1556 or USBR EM 7205), or as directed by the Engineer

2. Springline of pipe – By Sand Cone (ASTM D1556 or USBR EM 7205), or as directed by the Engineer

3. For cohesionless soils – By Sleeve Method (ASTM D4564 or USBR EM 7215), or as directed by the Engineer

4. Initial trench backfill – By Sand Cone (ASTM D1556 or USBR EM 7205) or by Nuclear Methods (ASTM D6938), as directed by the Engineer. Note that selection of density test will depend in part on distance from the pipe and potential for pipe interference with nuclear density measurements.

5. Final trench backfill – By Sand Cone (ASTM D1556 or USBR EM 7205) or by Nuclear Methods (ASTM D6938), as directed by the Engineer. Note that selection of density test will depend in part on distance from the pipe and potential for pipe interference with nuclear density measurements.

6. Fill outside of trenches, including embankments, structural fill and driving surfaces – By Nuclear Methods (ASTM D6938).

7. For silty or clayey soils containing more than 5% gravel: Results of unit weight corrected for oversized particle in accordance with ASTM D4718.

F. Percent compaction shall be determined by one of the following methods:

1. Comparison of in-place density of compacted material with maximum dry density of similar soil, as determined by Standard Proctor, ASTM D698.

2. Rapid Method: ASTM D5080 (USBR EM 7240)

G. Compaction testing frequency:

1. Minimum testing intervals shall be as follows:

   a. One test per compaction crew per day

   b. One test pit per 1000 LF of pipeline

   c. One test per 500 CY of structural fill or one test per lift, whichever results in greater testing frequency

2. Greater testing frequency is typically required at the beginning of new work, new personnel, new compaction methods or new equipment.

3. Additional tests may be required for areas suspected of having incomplete compaction or improper moisture content, or surfaces that may have become torn up subsequent to compaction efforts, at the direction of the Engineer.

4. Additional tests may be required for any reason at the discretion of the Engineer.

H. Contractor Support

1. At the direction of the Engineer, the Contractor shall provide inspection pits to check for voids under the haunches of the pipe and test pits to perform density and compaction testing at the springline and haunch areas of the pipe or against structure foundations.

   a. All test and inspection pits shall comply with all relevant OSHA safety requirements.

   b. Contractor shall provide warning lights, flags and other safety devices as needed by testing personnel.

   c. Upon completion of testing, Contractor shall backfill pits to original fill and backfill requirements.

2. When density is being measured by Sand Cone, Contractor shall cease construction activity in the immediate vicinity of testing.

3. The cost of all work associated with excavating, protecting and backfilling inspection and test pits, including implementation of safety requirements and time delays, shall be incidental to the unit price of the applicable pay item being tested, and shall be provided at no additional cost to the Owner.

4. Laboratory fees only shall be reimbursed to the Contractor from the Materials Testing Allowance bid item in accordance with Section 01 00 00 - Basic Requirements: Testing and Inspection Allowances. Other costs associated with testing, such as excavations, providing access, safety, time delays, transportation and other costs shall be considered incidental to the work.

3.9 CORRECTION OF SUB-STANDARD WORK

A. All fill and backfill represented by tests that fail to meet compaction, moisture content, soil classification or other specifications shall be uncovered as needed, replaced as needed, re-compacted and re-tested until all specifications are met, at no additional expense to the Owner.

1. Elevations, lines and grades of replaced material, as well as of pipe and other structures resting against such material, shall be re-surveyed at the direction of the Engineer, at Contractor's sole expense. Contractor shall correct elevations, lines and grades as needed, at Contractor's sole expense.

B. The cost of failed tests shall not be reimbursed by the Owner from the testing allowance.

3.10 PROTECTION OF FINISHED WORK

A. Section 01 00 00 - Execution Requirements: Protecting Installed Construction.

B. Reshape and re-compact fills subjected to vehicular traffic.

END OF SECTION

SECTION 31 23 25

SOIL CEMENT SLURRY / CONTROLLED LOW STRENGTH MATERIAL (CLSM)

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:

1. CLSM for:

a. Utility bedding.

b. Utility backfill.

B. Related Sections:

1. Section 31 23 17 - Trenching: Soil and aggregate backfill for utility trenches.

2. Section 31 23 23 - Backfill: Soil and aggregate backfill for structures.

1.2 UNIT PRICE - MEASUREMENT AND PAYMENT

A. CLSM:

1. Measurement: Volume measured in place to lines, grades, and dimensions shown on drawings or established by the Engineer.

2. Payment: Shall be considered incidental to the price of the items embedded in the CLSM. No separate payment shall be made.

1.3 REFERENCES

A. American Concrete Institute (ACI):

1. ACI 318 - Building Code Requirements for Structural Concrete

B. ASTM International:

1. ASTM C33 - Standard Specification for Concrete Aggregates.

2. ASTM C40 - Organic Impurities in Fine Aggregates for Concrete.

3. ASTM C94/C94M - Standard Specification for Ready-Mixed Concrete.

4. ASTM C114 - Chemical Analysis of Hydraulic Cement.

5. ASTM C143/C143M - Slump of Hydraulic Cement Concrete.

6. ASTM C150 - Standard Specification for Portland Cement.

7. ASTM C260 - Standard Specification for Air-Entraining Admixtures for Concrete.

8. ASTM C403/C403M - Standard Test Method for Time of Setting of Concrete Mixtures by Penetration Resistance.

9. ASTM C494/C494M - Standard Specification for Chemical Admixtures for Concrete.

10. ASTM C595 - Blended Hydraulic Cements.

11. ASTM C618 - Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete.
12. ASTM C1017/C1017M - Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete.
13. ASTM C1040 - Standard Test Methods for Density of Unhardened and Hardened Concrete In Place By Nuclear Methods.
14. ASTM C1602/C1602M - Mixing Water Used in the Production of Hydraulic Cement Concrete.
15. ASTM D558 - Standard Test Methods for Moisture-Density Relations of Soil-Cement Mixtures.
16. ASTM D1558 - Moisture Content Penetration Resistance of Fine Grained Soils
17. ASTM D4318 - Liquid Limit, Plastic Limit and Plasticity Index of Soils
18. ASTM D4832 - Standard Test Method for Preparation and Testing of Controlled Low Strength Material (CLSM) Test Cylinders.
19. ASTM D6024 - Ball Drop on Control Low Strength material (CLSM) to determine Suitability for Load Application
20. ASTM D6103 - Flow Consistency of Controlled Low Strength Material.

1.4 DEFINITIONS

A. The terms “Soil Cement Slurry” and “Controlled Low Strength Material” are used interchangeably in the contract documents.

1.5 SUBMITTALS

A. Section 01 00 00 - Submittal Procedures: Requirements for submittals.

B. Approval Data for CLSM Produced Without Native Soil:

1. Mix Design: For each CLSM Mix:

a. Mixture Proportions.

b. Material Sources:
1) Name and manufacturer of each cementitious material.
2) Name of aggregate sources.
3) Product name and manufacturer of admixtures to be used in mix.
4) Government reserves right to require submission of samples of CLSM materials for testing before or during use in concrete.

c. If proposed material has more than 30 percent passing the 200 sieve, provide mix designs for:
1) 10 to 30 passing 200 sieve
2) 30 to 50 passing 200 sieve

d. Physical properties:
1) Trial mixtures:
a) Results from trial batches made within past 6 months.
b) Trial mix test results, three 6 inch diameter, 12 inch high cylinders. each at 7 days and 28 days

c) Average compressive strength of trial batch cylinders at specified design age.

e. Resubmit mix design for change in material source or type.

f. Cementitious materials manufacturer's certifications and test reports within last 6 months.

g. Aggregate test reports for gradation and plasticity, less than 6 months old.

h. Method to determine moisture and consistency of materials to maintain specified strengths. Provide testing frequency.

2. If Quality control test results show CLSM does not meet requirements, submit revised mix design.

C. Approval Data for CLSM Produced With Native Soil:

1. Submit Mix design for each material type:

a. If proposed material has more than 30 percent passing the 200 sieve, provide mix designs for:
1) 10 to 30 percent passing 200 sieve.
2) 30 to 50 percent passing 200 sieve.

b. Physical properties:
1) Trial mixtures:
a) Results from trial batches made within past 6 months.
b) Trial mix test results, three 6 inch diameter, 12 inch high cylinders each at 7 days and 28 days.
c) Average compressive strength of trial batch cylinders at specified design age.

c. Resubmit mix design for change in material source or type.

d. Cementitious materials manufacturer's certifications and test reports within the last 6 months.

e. Material test reports for gradation and plasticity, less than 6 months old.

2. Soil processing and mixing equipment.

3. Foreman references.

4. Method to maintain specified strengths using native soils.

5. If quality control test results show CLSM does not meet specified requirements, submit revised mix design.

D. Quality Control Test Results:

1. Notify Resident Project Representative within 2 hours if testing does not meet specified requirements.

2. If Quality Control Test Results show CLSM does not meet specified requirements, submit a revised mix design.

E. Approval Data for method to prevent pipe flotation while placing CLSM.

1.6 DELIVERY, STORAGE AND HANDLING

A. For CLSM delivered from ready mix plants, furnish batch ticket with each batch of CLSM in accordance with ASTM C94. Deliver ticket to Resident Project Representative at jobsite prior to discharging material from the transport vehicle.

1.7 QUALIFICATIONS

A. References for foreman in charge of CLSM placement, if CLSM is produced with native soils: 3 projects within last 3 years.

PART 2 PRODUCTS

2.1 CEMENTITIOUS MATERIALS

A. Cement and pozzolan shipments shall be accompanied by shipping documents containing:

1. Manufactures Certification that material meets requirements.
2. Type or class of material shipped.
3. Manufacturing locations and dates.
4. Lot (bin) number.
5. Date of shipment.
6. Quantity of material shipped.
7. Provide to Resident Project Representative.

B. Cementitious Materials Option:

1. Specified Portland cement plus 20 to 80 percent by weight of total cementitious (cement plus pozzolan) specified pozzolan, in accordance with ACI 318.

C. Portland Cement:

1. ASTM C150, Type II.
2. Meet equivalent alkalies requirements of ASTM C150 - Table 2.
3. Meet false-set requirements of ASTM C150 - Table 4.

D. Pozzolan:

1. ASTM C618, Class F, except:
   a. Sulfur trioxide for Class F, maximum: 4.0 percent.
   b. Loss on ignition, maximum: 2.5 percent.
   c. Test for effectiveness in controlling alkali-silica reaction under optional physical requirements in Table 2 of ASTM C618. Use low-alkali cement for test.
   d. Does not decrease sulfate resistance of concrete by use of pozzolan.

1) Demonstration pozzolan will have an “R” factor less than 2.5.

2) R = (C-5)/F

3) C: Calcium oxide content of pozzolan in percent determined in accordance with ASTM C114.

4) F: Ferric oxide content of pozzolan in percent determined in accordance with ASTM C114.

2.2 WATER

A. Water: ASTM C1602, including optional requirements of Table 2.

2.3 AGGREGATE

A. Aggregate: ASTM C33

1. Maximum particle size: 1-1/2 inches or 1/8 of open distance between pipe and trench wall, whichever is less.

2.4 SOIL

A. Soil producing a color darker than the standard color when tested in accordance with ASTMC40: Not allowed.

B. Plasticity: Non-plastic or low plasticity (P.I. less than 5) in accordance with ASTM D4318.

C. Gradation:

1. Passing U.S. Standard N0. 200 sieve by weight, maximum: 50 percent.

2. Passing U.S. Standard No. 100 sieve by weight, maximum: 70 percent.

3. Maximum particle size: 1/8 of open distance between pipe and trench wall or 3/8 inch, whichever is less.

D. Select or process soil so that particles remain in suspension, i.e. no segregation occurs, when CLSM is placed.

E. Clay balls:

1. Maximum percent, by weight of soil: 10 percent.

2. Maximum size: 3/8 inch.

2.5 MIX

A. Mixture of Aggregate or Soil, Cementitious Materials, Water, and Admixtures:

1. Cementitious material content: Percent by dry weight of aggregate or soil to obtain specified compressive strength.

2. Make trial mixes prior to placing CLSM to determine mixture adequacy.

a. Determine compressive strength in accordance with ASTM D4832.

b. Determine slump in accordance with ASTM C143.

B. Water content: Not to exceed that required to provide a mix that will flow and can be pumped.

C. 7-day compressive strength, ASTM D4832: Not less than 50 psi and not more than 150 psi.

D. Consistency:

1. Except, when stiffer mix required to prevent CLSM from flowing down trenches on a steep slope:

a. Slump, ASTM C143: 8 to 10 inches.

2.6 CLSM TEMPERATURE

A. CLSM temperature at time of placement: 50 degrees to 85 degrees F (10 to 30 degrees C).

PART 3 EXECUTION

3.1 BATCHING EQUIPMENT

A. Design and operation of mixers: CLSM, as discharged, is uniform in composition and consistency throughout each batch.

1. Adjust amount of water and aggregates batched for CLSM to compensate for variations in moisture content or grading of aggregates as they enter mixer.

2. Inform Resident Project Representative prior to and after adjustments in batching equipment and control instrumentation.

3. Equip truck mixer with dial or digital water meter accurate to within 1 percent of total mix water located between water supply and mixer.

4. Provide revolution counter which indicates total number of revolutions of drum per batch.

a. Visible from outside truck.

b. Reset to zero for each batch.

5. Attach metal plate attached in a prominent place on the mixer listing:

a. Manufacturer's recommended drum capacity.

b. Mixing and agitating speeds in accordance with ASTM C94.

6. Initial Mixing: Not less than 70 revolutions and not more than 100 revolutions after ingredients are in the drum.

7. Mix 30 revolutions after addition of tempering water.

8. Mix 10 to 12 revolutions after a prolonged period of agitation.

9. Discharge CLSM before 300 drum revolutions

B. Manufacture and deliver in accordance with ASTM C94.

1. In addition to the requirements of ASTM C94, use a water meter approved by the Resident Project Representative to measure and record mix water for each batch.

C. Provide following information to Resident Project Representative:

1. Copy of current calibration of scales and water meters.
2. Mix water information.

3.2 TRIAL BATCH

A. Perform trial run with proposed equipment and material prior to placing CLSM.

1. Obtain Representative Sample of Material:
   a. If native soil materials are used, mix material from top of trench to proposed invert.
      1) Discard plastic material.
   b. Test material for gradation, plasticity.
2. Test CLSM for slump and compressive strength.
   a. Prepare and test three 6 by 12 inch cylinders for both 7 and 28 day according to ASTM D4832.

3.3 PREPARATION

A. Place pipe on soil pads or other approved compressible material such as extruded polystyrene foam insulation. Soil pads shall maintain horizontal and vertical alignment during backfilling operations.

1. Do not create point loads on the pipe.
   a. Soil pads shall have a lower compressible strength than the surrounding CLSM.

3.4 PLACING

A. Notify Resident Project Representative at least 24 hours before batching CLSM. Include quantity of CLSM required for each daily placement.

B. Do not place CLSM during rain or on frozen ground.

C. Do not mix or place CLSM when ambient temperature is below 40 degrees F. When ambient temperature is 35 degrees F or above, CLSM may be placed when ambient temperature is rising with approval from Resident Project Representative.

D. Place CLSM to lines, grade, and dimensions shown on drawings.

1. Initially, place CLSM from one side of pipe. Where necessary, rod or vibrate CLSM so that CLSM flows under pipe and appears on other side.
2. Add CLSM to both sides of pipe and rod or vibrate until CLSM completely fills space between pipe and trench.
3. Ensure that CLSM flows freely from one side of the pipe to the other.
4. Do not disturb trench or allow foreign material to become entrained in the CLSM.

E. Do not allow the pipe to float or move.

1. The Engineer may limit the length of pipe that can be laid or embedded with CLSM in advance of backfilling operations to prevent flotation, or may require the Contractor to place the CLSM in layers to prevent flotation or movement.
2. Restrain pipe to prevent flotation or movement during and after placement of CLSM.
3. Pipe that has floated or moved after surveying shall be re-surveyed at the direction of the Engineer to ensure compliance with specified lines and grades. Contractor shall correct lines and grades, and pipe shall be re-surveyed after such correction, as needed. All re-surveying shall be done at Contractors' sole expense.
4. Do not disturb pipe trench or allow foreign material to become mixed with CLSM.
5. Do not point load pipe.

F. Do not place backfill material over CLSM until CLSM has reached initial set.

1. As determined by ASTM D6024 (ball drop test) or ASTM D1558 in the presence of the Resident Project Representative.
2. Do not place greater than 10 feet of backfill over the pipe until the CLSM has a compressive strength of 50 pounds per square inch or greater.

3.5 CONTRACTOR FIELD QUALITY TESTING

A. Testing:

1. Independent testing laboratory shall perform sampling, testing, and reporting
2. If CLSM Contains Native Soils:
   a. Obtain and test soil samples for gradation and plasticity once every 14 days at a minimum or if a change in soil is visually noted.
      1) Test material 14 days ahead of placement from top of trench to proposed invert.
   b. During CLSM batching, provide an inspector from testing laboratory to monitor soil characteristics and operations.
      1) Modify material and or batching operations as recommended by testing laboratory.
      2) Notify Resident Project Representative within 24 hours of modifications.
3. Obtain samples and test to determine compressive strength in accordance with ASTM D4832 and slump in accordance with ASTM C143.
   a. Testing frequency:
      1) At least once for each shift when placing CLSM.
      2) Once every 100 cubic yards or,
      3) If consistency of materials change.
   b. Acceptance Criteria:
      1) 7 day compressive strength, ASTM D4832:
         a) Not less than 50psi and not more than 150 psi.
         b) 70 percent of test cylinders shall exceed 75 psi.
   c. Make adjustments to mixture to comply with strength requirements.

d. Stop work if specified requirements are not met.

3.6 FIELD QUALITY ASSURANCE

A. The Contractor shall supply material samples to Resident Project Representative upon request for independent testing of compressive strength in accordance with ASTM D4832 and slump in accordance with ASTM C143.

3.7 PROTECTION

A. When subsequent lifts of CLSM are to be placed, maintain surface of CLSM in a moist condition by use of tarps or water mist until subsequent lift of CLSM is placed.

B. If backfill will not be placed over CLSM within 8 hours after initial set, place 6-inch minimum cover of moist backfill over CLSM. Maintain moisture in 6-inch soil cover until additional backfill is placed.

C. If ambient temperature is 50 degrees F or less, place 12-inch minimum additional cover of loose backfill over 6-inch moist backfill cover before end of workday. Do not allow CLSM to freeze.

END OF SECTION

SECTION 31 35 27

CABLE CONCRETE

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:

1. Cable concrete mats.

B. Related Sections:

1. Section 31 22 13 - Rough Grading.

2. Section 03 30 00 Cast-In-Place Concrete.

1.2 UNIT PRICE - MEASUREMENT AND PAYMENT

A. Cable concrete mats:

1. Basis of Measurement: By square yard of cable concrete mat for horizontal surface only. Wastage will not be paid for. Area of turn-downs are not included in quantities on Drawings and Bid Form and shall be considered incidental to the Contractor's price.

2. Basis of Payment: Includes cable concrete mat, geotextile, preparation of surface, compaction, placing of cable concrete mats, cable clamps, clips, anchors, lifting bar rental, mobilization and delivery.

B. Bid items for cable concrete mats or other specific erosion control features that appear on the Bid Form apply only to features designed and directed by the Engineer. They do not include preparation of the Storm Water Pollution Prevention Plan (SWPPP) or implementation of any Best Management Practices (BMPs) stipulated therein. Separate bid items are provided for preparation and implementation of the SWPPP. Contractor is wholly responsible to prepare and implement the SWPPP to the satisfaction of relevant governmental authorities for the prices given under the SWPPP bid items.

1.3 SUBMITTALS

A. Section 01 00 00 - Submittal Procedures: Requirements for submittals.

B. Product Data: Cable concrete materials.

1.4 QUALITY ASSURANCE

A. General:

1. Tests on concrete will be performed in accordance with all requirements of applicable ASTM standards for such tests, including but not limited to obtaining samples, temperature, slump, air entrainment, making and curing specimens, breaking concrete cylinders, and other as may be applicable.

2. The cost of all laboratory tests on cement, aggregates, and concrete, for the development of the mix design, will be borne by the Contractor. The laboratory must meet or exceed the requirements of ASTM C1077.

3. Test cylinders will be prepared one (1) test each day of placement for each mixture for the first 50 or less cubic yards and one (1) test for each additional 100 cubic yards of concrete.

B. Compression Tests:

1. Compression test specimens will be taken during construction from the first placement of each class of concrete specified herein and at intervals thereafter as indicated above to ensure continued compliance with these specifications. Each set of test specimens will be a minimum of 5 cylinders.

2. Compression test specimens for concrete shall be made in accordance with ASTM C31. Specimens shall be 6-inch diameter by 12-inch high cylinders.

3. Compression tests shall be performed in accordance with ASTM C39. One test cylinder will be tested at 7 days, and 2 at 28 days. The remaining cylinders will be held to verify test results, if needed.

4. Compression testing will be paid for by the Owner.

C. Evaluation and Acceptance of Concrete:

1. Evaluation and acceptance of the compressive strength of concrete shall be according to the requirements of ACI 318, and as specified herein.

2. All concrete that fails to meet the ACI requirements and these specifications, is subject to removal and replacement at the cost of the Contractor.

3. Concrete delivered to the site that does not meet the requirements as herein specified may be rejected.

D. Visual Inspection:

1. A visual inspection of the mats shall be completed.

2. All mats shall be sound and free of defects that would interfere with the proper placing of the mats or impair the strength or performance of the construction.

3. Pin holes on the surface of the mats resulting from entrapped air in the wet cast procedure, surface cracks and any other incidental imperfections from the usual methods of manufacturing including surface chipping from handling the mats on the job site and in shipment and delivery, shall not be deemed grounds for rejection.

4. Cable concrete that does not meet the requirements as herein specified may be rejected.

PART 2 PRODUCTS

2.1 MATERIALS

A. Concrete:

1. Minimum 28- day compressive strength: 4,000 psi.

2. Minimum density: 140 lbs/cf

3. Air entrainment- all concrete shall contain 5.5% +/- 1.5% entrained air of evenly dispersed air bubbles at the time of placement.

4. Concrete Materials: Refer to Technical Specification 03 30 00 – Cast-In-Place Concrete.

5. Blocks shall be 15.5” square at the base and 11.5” square at the top face (truncated pyramid shape), and have a height of 5.5”.

6. The blocks shall be spaced 0.5” at the base.

7. Weight: 52 lbs per square foot

B. Geotextile Fabric:

1. 8 oz. per square yard.

2. Needle punched non-woven geotextile fabric.

3. Shall be attached to the bottom of the articulated concrete mat during production.

4. An overlap of 2’ to 3’ shall be incorporated on three sides of the mat. The overlap shall provide an area for the adjoining mats to be placed upon and prevent undermining of the erosion control system.

C. Cables:

1. Cables shall be made of stainless steel aircraft cables of type 304, shall be 1 x 19 construction, with 3/16” diameter, and 4,700 lbs breaking strength.

2. Cables shall be integral (poured into) to the concrete block, and shall traverse through each block in both longitudinal and lateral directions of the mat system.

D. Clamps:

1. Stainless steel clamps shall be used to secure loops of adjoining cable concrete mats.

   a. The standard placement of clamps shall be placed on 4’ centers interlocking adjoining mats together.

   b. The clamps are required only in applications exceeding 10’ per section. In slope applications greater than 2 to 1 where the mats are placed end to end, clips shall be placed on 4’ centers interlocking adjoining mats together.

2. Position cable clamps as close to the base of the concrete block by sliding cable clamp down to the adjacent loops before tightening securely.

3. Stainless steel Type 304 shall be used.

PART 3 EXECUTION

3.1 INSTALLATION

A. Placement shall be in accordance with Manufacturer's recommendations.

B. Do not place cable concrete mats over spongy subgrade surfaces.

C. Surface erosion control locations, dimensions, and quantities shown on Drawings are approximations only, and are subject to change based on finished grade. Final quantities, dimensions, and locations of cable concrete mats to be determined in field by Engineer after installation of pipeline and related facilities.

D. Prepared areas shall be graded to a smooth plane finish. Any roots, debris and stones must be removed and regarded. The mats shall be laid in such a manner to produce a smooth plane surface.

E. The gaps between each cable concrete mat shall not be greater than 1".

F. For at-grade installations, where approved by Engineer, the upstream and downstream edges of the mat system shall be keyed into the ground at a 45°angle for a length of 2 block rows on both the upstream and downstream edges, or as shown on Drawings.

G. For buried installations at wash crossings, the upstream edge shall be turned down vertically for 2 block rows, and the downstream edge shall be turned down vertically for 1 block row, or as shown on Drawings.

3.2 FIELD QUALITY CONTROL

A. Cracks exceeding 0.25 inches (0.635 cm) in width and/or 1.0 inch (2.54 cm) in depth, shall be deemed grounds for rejection.

B. Chipping resulting in a weight loss exceeding 10% of the average weight of the blocks shall be deemed grounds for rejection.

END OF SECTION

SECTION 31 37 00

RIPRAP AND ROCK LINING

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:

1. Riprap placed loose.

2. Wire Caged Riprap.

B. Related Sections:

1. Section 31 22 13 - Rough Grading.

2. Section 31 23 23 - Backfill.

3. Section 31 23 17 - Trenching.

1.2 UNIT PRICE - MEASUREMENT AND PAYMENT

A. Check dams and riprap placed loose:

1. Basis of Measurement: By cubic yard of riprap volume, riprap only.

2. Basis of Payment: Includes preparation of surface, compaction, placing of riprap material.

B. Wire caged rip rap:

1. Riprap:

a. Basis of Measurement: By cubic yard of riprap volume, riprap only.

b. Basis of Payment: Includes preparation of surface, compaction, placing of riprap material.

2. Wire mesh, geotextile, tie wire, angle iron, and other appurtenances:

a. Basis of Measurement: By square yard of riprap area encaged in completed installation. Wastage will not be paid for.

1) Measurement is based on actual coverage area. Where the Drawings require wire mesh both above and below the riprap blanket, both layers are included the pay item, but the coverage area is not doubled for purposes of measurement.

b. Basis of Payment: Includes cutting and placement of wire mesh material both above and below the riprap, geotextile fabric, tie wires, and angle irons.

C. Bid items for riprap, rock check dams or other specific erosion control features that appear on the Bid Form apply only to features designed and directed by the Engineer. They do not include preparation of the Storm Water Pollution Prevention Plan (SWPPP) or implementation of any Best Management Practices (BMPs) stipulated therein. Separate bid items are provided for preparation and implementation of the SWPPP. Contractor is wholly responsible to prepare and implement the SWPPP to the satisfaction of relevant governmental authorities for the prices given under the SWPPP bid items.

1.3 SUBMITTALS

A. Section 01 00 00 - Submittal Procedures: Requirements for submittals.

B. Product Data: Gradation of rock.

1.4 QUALITY ASSURANCE

A. Furnish each aggregate material from single source throughout the Work.

B. Perform Work in accordance with State of New Mexico Department of Transportation standard, if related to roadway construction or drainage.

C. Samples of riprap material shall be provided to the Engineer for inspection and approval for every 500 cubic yards of riprap delivered to the site.

D. Submit representative samples of riprap for testing using the Los Angeles Abrasion Test using ASTM-C131 and for Soundness Testing using ASTM C-88.

1. Loss of aggregate from abrasion test shall not exceed 40 percent. Sample results shall be provided to the Engineer for every 500 cubic yards of riprap delivered to the site.

2. Loss of aggregate for soundness test shall not exceed 15 percent. Sample results shall be provided to the Engineer for every 500 yards of riprap delivered to the site.

3. Riprap testing shall be covered under the testing allowance.

PART 2 PRODUCTS

2.1 MATERIALS

A. Furnish materials in accordance with State of New Mexico Department of Transportation standards, Section 602.

B. Riprap:

1. Shall comply with New Mexico Department of Transportation standards, Section 602.2

2. Irregular shaped rock:

a. Minimum size (as measured in the smallest dimension):

1) Class A Wire enclosed riprap:

a) D_{50} = 9” rock dimension. Remaining smaller rock shall not be smaller in any dimension than the smallest mesh openings.

2) Uncaged riprap and rock check dams:

a) D_{50} = 9” rock dimension, measured in the smallest dimension.

b. Solid and nonfriable.

C. Wire mesh:

1. Non-raveling, uniform, hexagonal double-twisted galvanized wire mesh, with a diameter of at least 0.087", with 2½" x 3¼" mesh openings.

2. Shall comply with New Mexico Department of Transportation standards, Section 602.2.2.2

D. Selvedges:

1. Selvedge wire with a diameter of at least 0.150-inch.

2. Shall comply with New Mexico Department of Transportation standards, Section 602.2.2.2.3

E. Stakes:

1. 4"x4"x3/8" angle iron, per New Mexico Department of Transportation standard, Section 602.

2. Lengths per Drawings.

F. Tie Wire:

1. Soft tempered Class 3 zinc coated 0.120-inch diameter tie wire.

G. Geotextile Fabric:

1. Provide non-woven geotextile (filter fabric) Class 1, as per New Mexico Department of Transportation standards, Section 604.

PART 3 EXECUTION

3.1 EXAMINATION

A. Section 01 00 00 - Administrative Requirements: Verification of existing conditions before starting work.

B. Do not place riprap over frozen or spongy subgrade surfaces.

3.2 PLACEMENT

A. Riprap locations, dimensions, and quantities shown on Drawings are approximations only, and are subject to change based on finished grade. Final quantities, dimensions, and locations of riprap to be determined in field by Engineer after installation of pipeline and related facilities.

B. Filter fabric:

1. Place Class 1 non-woven geotextile (filter fabric) between the riprap and the supporting soil.

C. Installed Thickness: As shown on Drawings, or as directed in field by Engineer.

D. Wire enclosure: Where wire enclosure is to be used, enclose rock in wire mesh and anchor in place as indicated on Drawings.

E. Class A Riprap Placement

1. Shall comply with New Mexico Department of Transportation standards, Section 602
2. Enclose Class A riprap with wire mesh drawn tightly on all sides. The Contractor may connect wire mesh using approved fasteners or lacing wire. Weave adjacent edges at least once with double loops of lacing wire that is as strong and flexible as the mesh.
3. Provide continuous lacing as far as possible that passes through each mesh opening. Where splicing is necessary, overlap the lacing at least 12 inches.
4. Space galvanized wire ties connecting top and bottom mesh layers approximately 24 inches on centers. Anchor the ties to the bottom wire-fabric layer. Extend the ties through the rock layer and secure to the top wire-fabric layer. Anchor wire-enclosed riprap to slopes with steel stakes driven into the Embankment. Space stakes in accordance with the Contract.

END OF SECTION

SECTION 32 11 23

AGGREGATE BASE COURSE AND GRAVEL

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:

1. Aggregate base course.

2. Clean gravel.

B. Related Sections:

1. Section 31 22 13 - Rough Grading: Preparation of site for base course.

2. Section 31 23 17 - Trenching: Compacted fill under base course.

3. Section 31 23 23 - Backfill: Compacted fill under base course.

1.2 UNIT PRICE - MEASUREMENT AND PAYMENT

A. Aggregate Base Course:

1. Basis of Measurement: By the square yard to depth indicated on Drawings.

2. Basis of Payment: Includes supplying fill material, stockpiling, scarifying substrate surface, placing aggregate to the depths and at the locations indicated on the Drawings, and compacting.

B. Clean Gravel

1. Basis of Measurement: By the square yard to depth indicated on Drawings.

2. Basis of Payment: Includes supplying fill material, stockpiling, placing gravel to the depths and at the locations indicated on the Drawings, and compacting.

1.3 REFERENCES

A. New Mexico Department of Transportation (NMDOT) Standard Specifications for Highway and Bridge Construction.

B. American Association of State Highway and Transportation Officials:

1. AASHTO T180 - Standard Specification for Moisture-Density Relations of Soils Using a 10-lb Rammer and an 18-in. Drop.

C. ASTM International:

1. ASTM D698 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft3 (600 kN-m/m3)).

2. ASTM D6938 - Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

1.4 SUBMITTALS

A. Section 01 00 00 - Submittal Procedures: Requirements for submittals.

B. Materials Source: Submit name of imported materials suppliers.

C. Manufacturer's Certificate: Certify Products meet or exceed specified requirements.

1.5 QUALITY ASSURANCE

A. Furnish each aggregate material from single source throughout the Work.

B. Perform Work in accordance with NMDOT standards.

PART 2 PRODUCTS

2.1 MATERIALS

A. Aggregate Base Course:

1. Base course gradation shall have a percent passing sieve sizes as shown in TABLE 304, SECTION 304-BASE COURSE, New Mexico Department of Transportation Standard Specifications for Highway and Bridge Construction, latest edition.

B. Clean Gravel (Class I crushed stone):

1. Manufactured angular, crushed stone, crushed rock, or crushed slag with the following gradation requirements.

Sieve Size	Percentage Passing
3/4-inch	100
No. 4	30 – 50
No. 200	0 - 5

PART 3 EXECUTION

3.1 EXAMINATION

A. Section 01 00 00 - Administrative Requirements: Verification of existing conditions before starting work.

B. Verify substrate has been inspected, gradients and elevations are correct, and is dry.

3.2 PREPARATION

A. Correct irregularities in substrate gradient and elevation by scarifying, reshaping, and re-compacting.

B. Do not place fill on soft, muddy, or frozen surfaces.

C. Subgrade surface shall be kept at all times in such manner that it will drain readily and effectively.

D. Mix aggregate material to provide a homogenous mixture of uniformly dispersed materials as placed in position for compacting.

3.3 AGGREGATE PLACEMENT

A. Spread aggregate over prepared substrate in layers that will permit the required density be obtained. Density requirements will be determined by AASHTO T-180.

B. Compact each layer of material full width with: (1) two passes of a 50 ton compression type roller, or (2) two passes of a vibratory roller having a minimum dynamic force of 40,000 pounds impact per vibration and a minimum frequency of 1,000 vibrations per minute, or (3) eight passes of a 10 ton compression-type roller, or (4) eight passes of a vibratory roller having a minimum dynamic force of 30,000 pounds impact per vibration and a minimum frequency of 1,000 vibrations per minute.

C. No displacement (pumping) of subgrade soils shall be visually observed when loaded by heavy equipment traffic.

D. Level and contour surfaces to elevations and gradients indicated.

E. Incorporate only suitable roadway excavation material into embankments. Compact material placed in all embankment layers and the material scarified in cut sections to a uniform density of not less than 95% Standard Proctor density.

F. Add small quantities of fine aggregate to coarse aggregate as appropriate to assist compaction.

G. Maintain optimum moisture content of fill materials to attain required compaction density.

H. Use mechanical tamping equipment in areas inaccessible to compaction equipment.

3.4 TOLERANCES

A. Section 01 00 00 - Quality Requirements: Tolerances.

B. Maximum Variation from Flat Surface: 3/8 inch measured with 10-foot straight edge in any direction.

C. Maximum Variation from Thickness: 1/2 inch.

3.5 FIELD QUALITY CONTROL

A. Section 01 00 00 - Execution Requirements: Testing, adjusting, and balancing.

B. Field testing of density and moisture content of in-place material will be performed in accordance with Nuclear Method, ASTM D6938.

C. When tests indicate Work does not meet specified requirements, remove Work, replace and retest.

D. Frequency of Tests: One test every 2,500 square feet or portion thereof, at locations directed by Engineer.

END OF SECTION

SECTION 32 31 13

CHAIN LINK FENCES AND GATES

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:

1. Fence framework, fabric, and accessories.
2. Excavation for post bases.
3. Concrete foundation for posts.
4. Manual gates and related hardware.
5. Removal, relocation, salvage, and/or reconstruction of existing fence.

1.2 UNIT PRICE - MEASUREMENT AND PAYMENT

A. Fencing:

1. Basis of Measurement: By linear foot to fence height specified, based on specified post spacing.
2. Basis of Payment: Includes posts, rails, tension wire, fabric, gates, hardware, accessories, and attachments.

1.3 REFERENCES

A. ASTM International:

1. ASTM A121 - Standard Specification for Zinc-Coated (Galvanized) Steel Barbed Wire.
2. ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
3. ASTM A153/A153M - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
4. ASTM A392 - Standard Specification for Zinc-Coated Steel Chain-Link Fence Fabric.
5. ASTM A491 - Standard Specification for Aluminum-Coated Steel Chain-Link Fence Fabric.
6. ASTM A585 - Standard Specification for Aluminum-Coated Steel Barbed Wire.
7. ASTM A792/A792M - Standard Specification for Steel Sheet, 55% Aluminum-Zinc Alloy-Coated by the Hot-Dip Process.
8. ASTM 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.

9. ASTM B429 - Standard Specification for Aluminum-Alloy Extruded Structural Pipe and Tube.
10. ASTM C94 - Standard Specification for Ready-Mixed Concrete.
11. ASTM F567 - Standard Practice for Installation of Chain-Link Fence.
12. ASTM F668 - Standard Specification for Poly (Vinyl Chloride) (PVC)-Coated Steel Chain Link Fence Fabric.
13. ASTM F900 - Standard Specification for Industrial and Commercial Swing Gates.
14. ASTM F934 - Standard Specification for Standard Colors for Polymer-Coated Chain Link Fence Materials.
15. ASTM F1043 - Standard Specification for Strength and Protective Coatings on Metal Industrial Chain Link Fence Framework.
16. ASTM F1083 - Standard Specification for Pipe, Steel, Hot-Dipped Zinc-Coated (Galvanized) Welded, for Fence Structures.
17. ASTM F1184 - Standard Specification for Industrial and Commercial Horizontal Slide Gates.

B. Chain Link Fence Manufacturers Institute:

1. CLFMI - Product Manual.

1.4 SYSTEM DESCRIPTION

A. Fence Height: 8 feet nominal.

B. Line Post Spacing: At intervals not exceeding 10 feet.

C. Vehicle Gates: 20 ft double-swing, consisting of two (2) 10 ft swinging sections.

1.5 SUBMITTALS

A. Section 01 00 00 - Submittal Procedures: Requirements for submittals.

B. Shop Drawings: Indicate plan layout, spacing of components, post foundation dimensions, hardware anchorage, gates, and schedule of components.

C. Product Data: Submit data on fabric, posts, accessories, fittings and hardware.

1.6 CLOSEOUT SUBMITTALS

A. Section 01 00 00 - Execution Requirements: Closeout procedures.

B. Project Record Documents: Accurately record actual locations of property perimeter posts relative to property lines and easements.

C. Operation and Maintenance Data: Procedures for submittals.

1.7 QUALITY ASSURANCE

A. Supply material in accordance with CLFMI - Product Manual.

B. Perform installation in accordance with ASTM F567.

1.8 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing Products specified in this section with minimum three years documented experience.

B. Installer: Company specializing in performing work of this section with minimum three years documented experience.

1.9 DELIVERY, STORAGE AND HANDLING

A. Section 01 00 00 - Product Requirements: Requirements for transporting, handling, storing, and protecting products.

B. Deliver fence fabric and accessories in packed cartons or firmly tied rolls.

C. Identify each package with manufacturer’s name.

D. Store fence fabric and accessories in secure and dry place.

PART 2 PRODUCTS

2.1 MATERIALS

A. Framing Steel: ASTM F1083 Schedule 40 galvanized steel pipe, welded construction; coating conforming to ASTM F1043 Type A on pipe exterior and interior.

B. Fabric Wire Steel: ASTM A392 zinc coated wire fabric.

C. Barbed Wire: ASTM A121 galvanized steel or ASTM A585 aluminum coated steel; 12 gage thick wire, 3 strands, and 4-point 14 gage barbs at approximately 5 inches on-center.

D. Concrete: 3,000 psi concrete.

2.2 COMPONENTS

A. Line Posts: 2.38-inch diameter.

B. Corner and Terminal Posts: 2.88 inch.

C. Gate Posts: 4.0-inch diameter.

D. Horizontal Rail: 1.66-inch diameter, plain end, sleeve coupled.

E. Gate Frame: 1.66-inch diameter for fittings and truss rod fabrication.

F. Fabric: 2-inch diamond-mesh interwoven wire, 9-gauge thick, top salvage twisted tight, bottom selvage knuckle end closed.

G. Tension Wire: 7-gauge thick steel, single strand, galvanized.

H. Tie Wire: Aluminum alloy steel wire.

2.3 ACCESSORIES

A. Caps: Cast steel, pressed steel, or malleable iron; galvanized, sized to post diameter, set screw retainer.

B. Fittings: Sleeves, bands, clips, rail ends, tension bars, fasteners and fittings; galvanized steel.

C. Extension Arms: Galvanized cast steel or pressed steel, to accommodate 3 strands of barbed wire, single arm, sloped to 45 degrees.

D. Gate Hardware: Center gate stop and drop rod; two 180-degree gate hinges for each leaf.

E. Chain: Provide chain for gate.

2.4 GATES

A. General:

1. Gate Types, Opening Widths and Directions of Operation: As indicated on Drawings or by Engineer in the field.

2. Factory-assembled gates.

3. Design gates for operation by one person.

B. Swing Gates:

1. Fabricate gates to permit 180-degree swing.

2. Gates Construction: ASTM F900 with welded corners. Use of corner fittings is not permitted.

3. Gate center stop: Mushroom type, galvanized cast iron, 1 3/8” slot, 4” long anchor

2.5 FINISHES

A. Components and Fabric: Galvanized to ASTM A123/A123M; ASTM A153/A153M for components; ASTM A392 for fabric; 2.0 oz/sq ft coating.

B. Hardware: Galvanized to ASTM A153/A153M, 2.0 oz/sq ft coating.

C. Accessories: Same finish as framing.

PART 3 EXECUTION

3.1 INSTALLATION

A. Install framework, fabric, accessories and gates in accordance with ASTM F567.

B. Set intermediate, terminal, and gateposts plumb, in concrete footings with top of footing 1 inch above finish grade of base course and 1 inch below top of gravel. Slope top of concrete for water runoff.

C. Line Post Footing Depth below Finish Grade: ASTM F567.

D. Corner, Gate and Terminal Post Footing Depth below Finish Grade: ASTM F567.

E. Brace each gate and corner post to adjacent line post with horizontal center brace rail and diagonal truss rods. Install brace rail one bay from end and gateposts.

F. Install top rail through line post tops and splice with 6-inch long rail sleeves.

G. Install center and bottom brace rail on corner gate leaves.

H. Place fabric on outside of posts and rails.

I. Do not stretch fabric until concrete foundation has cured 7 days.

J. Stretch fabric between terminal posts or at intervals of 100 feet maximum, whichever is less.

K. Position bottom of fabric 1 inch above finished base course grade.

L. Ensure final grade of gravel is 1 inch above bottom of fence material, leaving the fence fabric embedded 1 inch into the 2-inch thick gravel layer.

M. Fasten fabric to top rail, line posts, braces, and bottom tension wire with tie wire at maximum 15 inches on centers.

N. Attach fabric to end, corner, and gateposts with tension bars and tension bar clips.

O. Install bottom tension wire stretched taut between terminal posts.

P. Install support arms sloped outward and attach barbed wire; tension and secure, with barbed wire installed with lowest strand not less than 8 feet from ground level.

Q. Support gates from gateposts. Do not attach hinged side of gate from building wall.

R. Install gate with fabric and barbed wire overhang to match fence. Install three hinges on each gate leaf.

S. Provide concrete center drop to footing depth and drop rod retainers at center of double gate openings, if double gates are called for on the Drawings.

 1. Use mushroom-type gate center stop, set in concrete.

T. Install posts with 6 inches maximum clear opening from end posts to buildings, fences and other structures.

U. Excavate holes for posts to diameter and spacing indicated on Drawings without disturbing underlying materials.

V. Center and align posts. Place concrete around posts, and vibrate or tamp for consolidation. Verify vertical and top alignment of posts and make necessary corrections.

W. Extend concrete footings 2 inches above grade, and trowel, forming crown to shed water.

X. Allow footings to cure minimum 7 days before installing fabric and other materials attached to posts.

3.2 REMOVING EXISTING FENCE

A. All existing fences to be removed shall be recorded photographically or by video prior to removal or modification, to document pre-existing condition.

B. Existing fences requiring removal and reconstruction shall be rebuilt to the same condition as the original fence or better.

C. The materials in existing fences to be removed and rebuilt shall be salvaged and incorporated in the rebuilt fences. Fence materials damaged beyond reuse during removal or handling must be replaced at no additional expense to the Owner.

D. The costs associated with the removal and rebuilding of existing fences at the original location is considered incidental to the construction of the utility. If the fence is relocated as instructed by the Engineer, a separate bid item will be included in the Bid Schedule.

E. Existing fence materials to be removed that will not be reused within the project shall be provided to the Owner at a location within the project area specified by the Owner. Contractor shall take reasonable care to avoid damage to removed materials, so that the Owner may reuse such materials at another location. Costs to transport and reinstall removed materials outside the project area shall be borne by the Owner.

F. Posts shall be firmly reset to the line shown on the Drawings, or as directed by the Engineer. The spacing of the posts and the material to be strung and secured to the posts is to be the same as the original fence.

G. New tie material or staples must be used to fasten the fence material to the posts.

3.3 ERECTION TOLERANCES

A. Section 01 00 00 - Quality Requirements: Tolerances.

B. Maximum Variation From Plumb: 1/4 inch.

C. Maximum Offset From Indicated Position: 1 inch.

D. Minimum distance from property line: 6 inches.

END OF SECTION

SECTION 32 92 19

SEEDING

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:

1. Preparation of subsoil.
2. Placing topsoil.
3. Seeding, Hydroseeding, Seed Drilling.
4. Seed Protection, Mulching
5. Maintenance.

B. Related Sections:

1. Section 31 22 13 - Rough Grading: Rough grading of site.
2. Section 31 23 17 - Trenching: Rough grading over cut.
3. Section 31 23 23 - Backfill

1.2 UNIT PRICE - MEASUREMENT AND PAYMENT

A. Grassed Areas:

1. Basis of Measurement: By linear foot of centerline within the disturbed area of pipeline right of way and temporary use area. Lump sum for tank site.
2. Basis of Payment: Includes preparation of subsoil, topsoil, placing topsoil, seeding, watering and maintenance to specified time limit.

1.3 REFERENCES

A. Federal Specifications:

1. OF-241 - Fertilizers, Mixed, Commercial.
2. Farmington Field Office Bare Soil Reclamation Procedures, USBLM, January 2013.

B. ASTM International:

1. ASTM C602 - Standard Specification for Agricultural Liming Materials.

1.4 DEFINITIONS

A. Weeds: Vegetative species other than specified species to be established in given area.

B. NNAD: Navajo Nation Department of Agriculture

C. BLM: Bureau of Land Management, Farmington Field Office

1.5 SUBMITTALS

A. Section 01 00 00 - Submittal Procedures: Requirements for submittals.

1. Product Data: Submit data for seed mix, fertilizer, and other accessories.

1.6 QUALITY ASSURANCE

A. Provide seed mixture in containers showing percentage of seed mix, germination percentage, inert matter percentage, weed percentage, year of production, net weight, date of packaging, and location of packaging.

B. Perform Work in accordance with Navajo Nation Department of Agriculture and Bureau of Land Management standards.

C. Seed mixtures must be certified. There shall be no primary or secondary noxious weeds in the seed mixtures.

D. Temporary Best Management Practices (BMPs) must be installed along areas where sediment is being transported out of the construction area. Fiber rolls (mulch socks) rip rap blankets, rip rap check dams, soil cement, soil berms, surface roughening, or other appropriate BMPs shall be used in these areas. Such BMPs shall be included in the Storm Water Pollution Prevention Plan (SWPPP) provided and implemented by the Contractor.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Product storage and handling requirements shall be as specified in applicable sections of these Specifications and in accordance with recommendations of the supplier.

B. Deliver grass seed mixture in sealed containers. Seed in damaged packaging is not acceptable.

C. Deliver fertilizer in waterproof bags showing weight, chemical analysis, and name of manufacturer.

1.8 COORDINATION

A. Section 01 00 00 - Administrative Requirements: Requirements for coordination.

B. Do not commence seeding until all work that could require ground disturbance has been completed, tested, and approved.

C. Contractor is advised that there may be different seed mixtures depending on land status and native vegetation type. Contractor shall use Navajo Nation Department of Agriculture (NNAD) seed mix on tribal lands and Bureau of Land Management (BLM) seed mix on BLM lands. Selection of specific mixture will depend on existing vegetation and soil type at each location. Contractor shall coordinate with Engineer prior to purchasing seed to determine exactly where to use each seed mixture.

D. Contractor shall coordinate seeding dates to coincide with the dates stipulated in the NNAD and BLM re-vegetation requirements and stipulations.

1. Contractor shall indicate exact proposed re-seeding dates in project schedule, and shall notify the Engineer and BLM as early as possible of any deviations from this proposed seeding schedule.

E. BLM Concurrence: Contractor shall schedule follow up and final review by BLM for all seeding on BLM lands. Contractor shall abide by all stipulations and requirements by BLM for final inspection. At time of final inspection, Contractor shall coordinate Photo Point Monitoring at monitoring locations of BLM's choosing as described in Farmington Field Office Bare Soil Reclamation Procedures, USBLM, January 2013.

1.9 MAINTENANCE SERVICE

A. Section 01 00 00 - Execution Requirements: Requirements for maintenance service.

B. The cover will be maintained by occasional mowing, spot spraying, reseeding weak areas, or by controlled burns. Maintain seeded areas for three months from Date of Substantial Completion. Maintenance shall include weekly watering.

C. After the first full season of growth (not the first year) the cover should be mowed or grazed to control annual weeds to encourage good growth. Timing of mowing should avoid nesting times of birds (indicated in Environmental Requirements, Appendix C).

PART 2 PRODUCTS

2.1 SEED MIXTURE

A. Furnish materials in accordance with Navajo Nation Department of Agriculture and Bureau of Land Management standards.

B. Engineer, in consultation with BLM and NNAD, shall determine which seed mixture applies at each location within the project. Contractor is responsible to coordinate with Engineer to determine proper seed mix prior to purchasing seed.

C. In developing seed mixtures, the percentage of each included species should first be determined. This percentage, which should total 100, is then multiplied by the recommended seeding rate for the concerned species. This will give the required pounds PLS for that species in the mix.

2.2 SOIL MATERIALS

A. Topsoil: Excavated from site and free of weeds.

2.3 ACCESSORIES

A. Water: Clean, fresh and free of substances or matter capable of inhibiting vigorous growth of grass.

B. Erosion Fabric: Jute matting, open weave.

C. Herbicide: If required, Owner and Engineer's approval must be obtained prior to use.

D. Stakes: Softwood lumber, chisel pointed.

E. String: Inorganic fiber.

F. Mulch: Where allowed, shall be in accordance with BLM specifications and the SWPPP provided by the Contractor.
   1. Hydromulch shall not be permitted on any lands.
   2. Mulch of any kind shall not be used on Tribal lands.

PART 3 EXECUTION

3.1 GENERAL

A. Prepare and restore site per applicable NNAD and BLM Revegetation Plans.

1. Final acceptance of ROW seeding and restoration on BLM lands shall be at the discretion of the BLM.

B. Seed and reclaim all disturbed areas, including temporary construction easements and any areas disturbed by construction traffic.

C. Temporary fence gates along the pipeline alignment must be kept closed to manage the livestock in the pipeline area.

3.2 EXAMINATION

A. Verify prepared soil base is ready to receive the Work of this section.

3.3 PREPARATION OF SUBSOIL

A. Prepare sub-soil to eliminate uneven areas and low spots. Maintain lines, levels, profiles and contours. Make changes in grade gradual. Blend slopes into level areas. The heel of a boot should not sink in more than ½ to 1 inch.

B. Remove foreign materials, weeds and undesirable plants and their roots. Remove contaminated sub-soil.

C. Topsoil removed from the right-of-way must not be mixed with sagebrush debris which may impede seed germination during the revegetation process.

D. In areas needing reseeding, the top layer of soil shall be softened by ripping and disking prior to seeding to create the soil structure necessary to allow for seed germination.

E. Scarify subsoil to depth of 6 inches where topsoil is to be placed. Repeat cultivation in areas where equipment, used for hauling and spreading topsoil, has compacted sub-soil.

3.4 PLACING TOPSOIL

A. Spread topsoil to minimum depth of 6 inches over area to be seeded. Rake until smooth.

B. Place topsoil during dry weather and on dry unfrozen subgrade.

C. Remove vegetable matter and foreign non-organic material from topsoil while spreading.

D. Grade topsoil to eliminate rough, low or soft areas, and to ensure positive drainage.

3.5 SEEDING

A. Use seed mixture indicated by Engineer, based on land ownership and native vegetation.

B. Apply seed at rates specified by BLM and NNAD for their respective seed mixtures. Use seed drill followed by drag packer over area to incorporate seed approximately ½ inch deep.

C. Planting Season: See Article 1.8. of this Section.

D. Do not sow immediately following rain, when ground is too dry, or when winds are over 12 mph.

E. Seed placement rows on steep slopes should not be placed parallel to the down slope, but at angles to the down slope to prevent the formation of gullies and rills.

F. A seed drill followed by a drag packer shall be required unless specific exceptions are authorized in writing by the Engineer.

G. Some hand seeding may be needed along steep slopes where equipment is difficult to use.

H. Apply water with a fine spray immediately after each area has been seeded. Saturate to 4 inches of soil.

3.6 HYDROSEEDING

A. Hydroseeding shall only be allowed where it is physically unfeasible to seed drill.

B. Hydroseeding shall not be performed without prior written authorization by the Engineer.

C. Apply fertilizer and seeded slurry with hydraulic seeder at an approved rate evenly in one pass.

D. After application, apply water with fine spray immediately after each area has been hydroseeded. Saturate to 4 inches of soil and maintain moisture levels two to four inches.

E. If hydroseeding is used, the specified rates of seed application shall be doubled.

3.7 SEED PROTECTION

A. Cover seeded slopes where grade is 3:1 or greater with erosion fabric. Roll fabric onto slopes without stretching or pulling.

1. All slopes around the perimeters of tank site shall be covered with erosion fabric, regardless of grade.

B. Lay fabric smoothly on surface, bury top end of each section in 6-inch deep excavated topsoil trench. Overlap edges and ends of adjacent rolls minimum 12 inches. Backfill trench and rake smooth, level with adjacent soil.

C. Secure outside edges and overlaps at 36-inch intervals with stakes.

D. Lightly dress slopes with topsoil to ensure close contact between fabric and soil.

E. At sides of ditches, lay fabric laps in direction of water flow. Lap ends and edges minimum 6 inches.

F. Protection of seeded areas from traffic: Contractor shall take measures as required by the Owner, Engineer, and/or land controlling agencies to prevent traffic on re-seeded areas. Such measures may include warning signs, fence post barricades, earthen berms, and/or other measures at intersections of seeded ROW and existing roadways and driveways, and at other locations as directed by Engineer. Earthen berms shall extend the full width of the disturbed area, with dimensions as directed in field by Engineer.

G. All seed protection measures, including traffic prevention, shall be subject to approval of BLM and other land-controlling agencies.

3.8 MULCHING

A. Do not apply mulch on Tribal lands.

B. Apply mulch on BLM lands only to the extent allowed by BLM and recommended in the Storm Water Pollution Prevention Plan (SWPPP) provided by the Contractor.

C. Any mulching shall be anchored in place by crimping or other method approved by Engineer.

3.9 MAINTENANCE

A. Immediately reseed areas showing bare spots.

B. Repair washouts or gullies.

C. Protect seeded areas with warning signs during maintenance period.

3.10 SCHEDULE

A. All utility routes, disturbed areas, vault areas, and non-traveled areas in road rights-of-way to be reseeded when Work is completed in affected areas.

END OF SECTION

SECTION 33 05 23.13

HORIZONTAL DIRECTIONAL DRILLING

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:

1. Excavation for approach trenches and pits.

2. Horizontal directional drilling.

3. Pipe.

B. Related Sections:

1. Section 03 30 00 - Cast-in-Place Concrete: Concrete materials.

2. Section 03 60 00 - Grout.

3. Section 31 23 17 - Trenching.

4. Section 31 23 23 - Backfill.

5. Section 33 11 13- Public Water Transmission Systems.

6. Section 33 13 00 - Disinfection of Water Utility Distribution.

1.2 UNIT PRICE - MEASUREMENT AND PAYMENT

A. Horizontal Directional Drilling:

1. Basis of Measurement: By linear foot.

2. Basis of Payment: Includes excavation, drilling, carrier pipe, spacers, end seals, transition couplings, accessories, tests, and backfill.

1.3 REFERENCES

A. American Association of State Highway and Transportation Officials:

1. AASHTO T180 - Standard Specification for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop.

B. ASTM International:

1. ASTM D698 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft3 (600 kN-m/m3)).

2. ASTM D1557 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (6,000 ft-lbf/ft3 (2,700 kN-m/m3)).

3. ASTM D3350 - Standard Specification for Polyethylene Plastics Pipe and Fittings Materials.

4. ASTM D6938 - Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

5. ASTM F477 - Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.
6. ASTM F714 - Standard Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter.
7. ASTM F1962 - Standard Guide for Use of Maxi-Horizontal Directional Drilling for Placement of Polyethylene Pipe or Conduit under Obstacles, Including River Crossings.
8. ASTM F2620 - Standard Practice for Heat Fusion Joining of Polyethylene Pipe and Fittings.
9. ASTM F2634 - Standard Test Method for Laboratory Testing of Polyethylene (PE) Butt Fusion Joints using Tensile-Impact Method

C. American Water Works Association (AWWA):

1. AWWA C900 - Polyvinyl Chloride (PVC) Pressure Pipe, and Fabricated Fittings, 4 In. through 12 In. (100 mm through 300 mm), for Water Distribution.
2. AWWA M23 – PVC Pipe – Design and Installation

D. Plastics Pipe Institute (PPI):

1. Technical Report TR-33 - Generic Butt Fusion Joining Procedure for Field Joining of Polyethylene Pipe.

E. NSF International Standard / American National Standard (ANSI)

1. NSF/ANSI 61 – Drinking Water System Components – Health Effects

F. National Utility Contractors Association:

1. NUCA - HDD Installation Guidelines.

1.4 DESIGN REQUIREMENTS

A. Design Criteria:

1. Drilling Steering System: Remote with continuous electronic monitoring of boring depth and location.
2. Directional Change Capability: 90 degree with 250-foot radius curve, or minimum bending radius specified by manufacturer of the carrier pipe.
3. Ratio of Reaming Diameter to Pipe Outside Diameter:
   a. Nominal Pipe Diameter of 6 Inches and Smaller: 1.5 maximum.
   b. Nominal pipe diameter larger than 6 Inches: 1.5 maximum, submit recommended ratio and reaming procedures for review.

1.5 SUBMITTALS

A. Section 01 00 00 - Submittal Procedures: Requirements for submittals.

B. Shop Drawings:

1. Submit technical data for equipment, method of installation, proposed horizontal and vertical alignment and beginning and end points (if different than those shown on the plans), and proposed sequence of construction, including project schedule.
2. Include information pertaining to pits, dewatering, method of spoils removal, equipment size and capacity, equipment capabilities including installing pipe on radius, type of drill bit, drilling fluid, method of monitoring line and grade and detection of surface movement, name plate data for drilling equipment and mobile spoils removal unit, design requirements per Section 1.4 of this technical specification.

C. Contractor Qualifications: Submit history of previous work completed of equivalent nature and scope. Include qualification and experience of key personnel and references for work completed.

D. Manufacturer's technical data showing complete information on material composition, physical properties and dimensions of the new pipe and fittings. Manufacturer's recommendations for transport, handling, and storage of pipe and fittings shall be included.

E. Submit necessary occupancy permit for installations along or under public throughways and lands, and railroad right of way, if not already obtained by the Engineer.

F. Manufacturer's Certificate: Certify products meet or exceed specified requirements.

G. Contingency plans for the following potential conditions:

1. Unforeseen subsurface conditions.
2. Damage to other existing utilities.
3. Soil heaving or settlement.

1.6 CLOSEOUT SUBMITTALS

A. Section 01 00 00 - Execution Requirements: Requirements for submittals.

B. Project Record Documents: Record actual locations of casing or tunnel liner, carrier pipe, and invert elevations.

C. Identify and describe unexpected variations to subsoil conditions or discovery of uncharted utilities.

D. Record actual depth of pipe at 25 feet intervals.

E. Record actual horizontal location of installed pipe.

F. Show depth and location of abandoned bores.

G. Record depth and location of drill bits and drill stems not removed from bore.

1.7 QUALITY ASSURANCE

A. Perform work in accordance with the following:

1. Applicable New Mexico state standards
2. NUCA HDD Installation Guidelines.
3. ASTM F1962.

1.8 QUALIFICATIONS

A. Contractor: Company specializing in performing work of this section with minimum 5 years documented experience.

B. The Contractor must be certified by the HDD system manufacturer as a fully trained user of the HDD system. Operation of the HDD system shall be performed by trained personnel. Such training shall be conducted by a qualified representative of the HDD system manufacturer.

C. HDPE pipe jointing shall be performed by personnel trained in the use of butt-fusion equipment. Personnel directly involved with installing the new pipe shall receive training in the proper methods for joining the pipe. Such training shall be conducted by a qualified representative of the fusion equipment manufacturer. Installation of other materials shall be performed by personnel qualified by the specific product manufacturer.

D. HDD contractor shall have installed at least 5,000 LF.

E. HDD contractor must have experience installing HDPE pipe of similar diameter to that of the proposed project.

1.9 PRE-INSTALLATION MEETINGS

A. Section 01 00 00 - Administrative Requirements: Pre-installation meeting.

B. Convene minimum one week prior to commencing work of this section.

1.10 DELIVERY, STORAGE, AND HANDLING

A. Section 01 00 00 - Product Requirements: Requirements for transporting, handling, storing, and protecting products.

B. The Contractor shall transport, handle, and store pipe and fittings as recommended by the manufacturer.

C. New pipe and fittings that are damaged before or during installation shall be repaired or replaced, as recommended by the manufacturer or required by the Engineer. The costs of such repair or replacement shall be borne by the Contractor and be accomplished prior to proceeding with the project.

D. The Contractor shall deliver, store and handle other materials as required to prevent damage. Materials that are damaged or lost shall be repaired or replaced by the Contractor at no additional expense to the Owner.

E. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.

F. Protect piping system pieces from entry of foreign materials and water by temporary covers, completing sections of work, and isolating parts of completed system.

G. Accept products on site in manufacturer's original containers or configuration. Inspect for damage.

H. Store field joint materials indoors in dry area in original shipping containers. Maintain storage temperature of 60 to 85 degrees F.

I. Support pipes with nylon slings during handling.

1.11 ENVIRONMENTAL REQUIREMENTS

A. Section 01 00 00 - Product Requirements: Environmental conditions affecting products on site.

B. Conduct operations so as not to interfere with, interrupt, damage, destroy, or endanger integrity of surface or subsurface structures or utilities, and landscape in immediate or adjacent areas.

C. The Contractor shall comply with all other Federal, State, and local environmental requirements including, but not limited to, storm water runoff, construction dewatering, disposal of drilling fluid, and hazardous waste management and disposal.

1.12 COORDINATION

A. Section 01 00 00 - Administrative Requirements: Requirements for coordination.

B. Coordinate work with the New Mexico Department of Transportation (NMDOT), local Municipal Public Works Department (if applicable), and utilities within construction area.

PART 2 PRODUCTS

2.1 DRILLING FLUID

A. Drilling Fluid: Liquid bentonite clay slurry; totally inert with no environmental risk.

2.2 CARRIER PIPE

A. Furnish materials in accordance with New Mexico state standards.

2.3 POLYETHYLENE PLASTIC PIPE

A. Refer to Specification 33 11 13.

2.4 FILL MATERIALS

A. Excavated and reused soil with no rocks over 6 inches in diameter, frozen earth or foreign matter.

2.5 WATER SOURCE

A. Water: Potable.

2.6 UNDERGROUND PIPE MARKERS

A. Tracer Wire: Magnetic detectable conductor insulated with high density polyethylene (HDPE) or UF- XHHW in accordance with physical and electrical properties per ASTM D-1248.

1. Tracer wire shall be rated for “Direct Burial”, 30 volts, and be appropriate for installation in Horizontal Directional Drill (HDD) applications,

2. Tracer wire shall be constructed of copper clad hard drawn extra high strength (EHS) tracer wire with a steel core or engineer approved equal, and

3. Tracer wire must be appropriately sized and installed to be compatible with the pullback rating of the equipment being used.

B. Splice Connectors: Model LV 9500 Blazing Snap-locking waterproof connectors pre-filled with silicone or engineer approved equal.

PART 3 EXECUTION

3.1 EXAMINATION

A. Section 01 00 00 - Administrative Requirements: Verification of existing conditions before starting work.

B. Verify connection to existing piping system size, location, and invert elevations are in accordance with Drawings.

3.2 PREPARATION

A. Call Local Utility Line Information service at not less than three working days before performing Work.

1. Request underground utilities to be located and marked within and surrounding construction areas.

B. Locate, identify, and protect utilities indicated to remain from damage.

C. Identify required lines, levels, contours, and datum locations.

D. Protect bench marks, survey control points, existing structures, fences, sidewalks, paving, and curbs from excavating equipment and vehicular traffic.

3.3 DEWATERING

A. Intercept and divert surface drainage, precipitation, and groundwater away from excavation through use of dikes, curb walls, ditches, pipes, sumps or other means.

B. Develop and maintain substantially dry subgrade during drilling and pipe installation.

C. Comply with New Mexico state standards and requirements for dewatering to any watercourse, prevention of stream degradation, and erosion and sediment control.

3.4 EXISTING WORK

A. Maintain access to existing community facilities and homes as well as other remaining active installations requiring access. Modify installation as necessary to maintain access.

3.5 EXCAVATION

A. Excavate approach trenches and pits in accordance with shop drawings and as site conditions require. Minimize number of access pits.

B. Provide sump areas to contain drilling fluids.

C. Install excavation supports as specified in Section 31 23 17.

D. Restore areas after completion of drilling and carrier pipe installation.

3.6 DRILLING

A. Drill pilot bore with vertical and horizontal alignment as indicated on Drawings.

B. Guide drill remotely from ground surface to maintain alignment by monitoring signals transmitted from drill bit.

1. Monitor depth, pitch, and position.
   a. Monitor position every 5' along pilot bore.

2. Adjust drill head orientation to maintain correct alignment.

3. Monitor with Walkover system, or other proven type.
   a. System shall be setup and operated by personnel trained and experienced with system.
   b. Calibrate and verify electronic monitor accuracy in presence of Engineer before proceeding with other drilling. When required accuracy is not met, adjust equipment or provide new equipment capable of meeting required accuracy.

C. Inject drilling fluid into bore to stabilize hole, remove cuttings, and lubricate drill bit and pipe.

D. Continuously monitor drilling fluid pumping rate, pressure, viscosity, and density while drilling pilot bore, back reaming, and installing pipe to ensure adequate removal of soil cuttings and stabilization of bore.

1. Monitor down-hole.

2. Provide relief holes when required to relieve excess pressure.

3. Minimize heaving during pullback.

E. After completing pilot bore, remove pilot drill bit.

F. Install reaming drill bit and begin reaming bore hole to minimum diameter.

G. Minimum Reamer Size: 36-inch for 24-inch pipe, and 30-inch for 20-inch pipe.

H. HDD Machine shall be at least 100,000 pound machine.

3.7 DRILLING OBSTRUCTIONS

A. When obstructions are encountered during drilling, notify Engineer immediately. Do not proceed around obstruction without Engineer's approval.

B. For conditions requiring more than 12 inches deviation in horizontal or vertical alignment, notify Engineer immediately. Do not proceed around obstruction without Engineer's approval.

C. Maintain adjusted bore alignment within easement or right-of-way.

3.8 PIPE INSTALLATION

A. After reaming bore to minimum required bore diameter, remove drill bit. Install reamer with a swivel and pipe pulling head.

1. Select reamer with minimum bore diameter required for pipe installation.

B. Attach pipe to pipe pulling head. Pull reamer and pipe to entry pit along pilot bore.

C. Inject drilling fluid through reamer to stabilize bore and lubricate pipe.

D. Install piping with horizontal and vertical alignment as shown on Drawings.

E. Protect and support pipe being pulled into bore so pipe moves freely and is not damaged during installation.

F. Do not exceed pipe manufacturer’s recommended maximum pullback forces.

G. Do not exceed pipe manufacturer’s recommended minimum bending radius.

H. Install trace wire continuous with each bore. Splice trace wire only at intermediate bore pits. Tape or insulate trace wire to prevent corrosion and maintain integrity of pipe detection.

1. Terminate trace wire for each pipe run at structures along pipe system.
2. Provide extra length of trace wire at each structure, so trace wire can be pulled 3 feet out top of structure for connection to detection equipment.
3. Test trace wire for continuity for each bore before acceptance.

I. Provide sufficient length of carrier pipe, minimum 10’, to extend past termination point to allow connection to other pipe sections.

J. Allow minimum of 24 hours for stabilization after installing pipe before making connections to pipe.

K. Mark location and depth of bore with spray paint on paved surfaces, and wooden stakes on non-paved surfaces at 25-foot intervals.

3.9 HDPE FUSION PROCESS

A. Refer to Section 33 11 13.

3.10 SLURRY REMOVAL AND DISPOSAL

A. Contain excess drilling fluids at entry and exit points until recycled or removed from site. Provide recovery system to remove drilling spoils from access pits.

B. Remove, transport and legally dispose of drilling spoils.

1. Do not discharge drilling spoils in sanitary sewers, storm sewers, or other drainage systems.
2. When drilling in suspected contaminated soil, test drilling fluid for contamination before disposal.

C. When drilling fluid leaks to surface, immediately contain leak and barricade area from vehicular and pedestrian travel before resuming drilling operations.

D. Complete cleanup of drilling fluid at end of each workday.

3.11 DISINFECTION AND FLUSHING

A. Disinfection and flushing shall be conducted in accordance with Section 33 13 00.

3.12 PRESSURE AND LEAKAGE TESTING

A. Pressure and leakage testing shall be conducted in accordance with Section 33 11 13 as applicable. Pipe shall be pressure and leakage tested on surface, after pipe sections have been fused, but prior to pipe HDD installation.

3.13 BACKFILL

A. Install backfill as specified in Section 31 23 17 and 31 23 23.

B. Backfill approach trenches and pits with subsoil fill to contours and elevations of surrounding existing grade.

C. Compact subsoil fill as specified in Section 31 23 23 to minimum 95 percent of maximum density.

3.14 INSTALLATION TOLERANCES

A. Section 01 00 00 - Quality Requirements: Tolerances.

B. Maximum Variation From Horizontal Position: 12 inches.

C. Maximum Variation From Vertical Elevation: 12 inches.

D. Minimum Horizontal and Vertical Clearance from Other Utilities: 24 inches.

E. When pipe installation deviates beyond specified tolerances, abandon bore, remove installed pipe, re-bore, and reinstall pipe in correct alignment.

F. Fill abandoned bores greater than 3 inches in diameter with grout or flowable fill material.

3.15 FIELD QUALITY CONTROL

A. Section 01 00 00 - Execution Requirements: Testing, adjusting, and balancing.

B. Compaction Testing: As specified in Section 31 23 23.

C. When tests indicate Work does not meet specified requirements, remove Work, replace and retest.

3.16 MANUFACTURER'S FIELD SERVICES

A. Section 01 00 00 - Quality Requirements: Requirements for manufacturer’s field services.

B. Furnish field technical assistance during following periods of installation:

1. Unloading of materials and components.

2. Prior to commencing excavation and during excavation as requested.

C. Certify that equipment for drilling has been properly set-up and is ready for drilling.

3.17 CLEAN-UP

A. Upon completion of drilling and pipe installation, remove drilling spoils, debris, and unacceptable material from approach trenches and pits. Clean up excess slurry from ground.

B. Restore approach trenches and pits to original condition.

C. Remove temporary facilities for drilling operations.

END OF SECTION

SECTION 33 11 13

PUBLIC WATER TRANSMISSION SYSTEMS

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:

1. Pipe and fittings for public line including potable water line.
2. Tapping Sleeves and Saddles.
3. Corrosion Protection and Monitoring Systems.
4. Underground and Aboveground Pipe Markers.
5. Bedding and Cover Materials.
6. Source Quality Control and Assurance.

B. Related Sections:

1. Section 02 21 13 - Surveying.
2. Section 03 30 00 - Cast-in-Place Concrete: Thrust restraints.
3. Section 31 23 17 - Trenching: Execution requirements for trenching.
4. Section 31 23 23 - Backfill: Requirements for backfill to be placed.
5. Section 32 92 19 - Seeding.
6. Section 33 12 16 - Water Utility Valves.
7. Section 33 13 00 - Disinfection of Water Utility Transmission Systems.
8. Section 31 32 35 – Soil Cement Slurry / CLSM

1.2 UNIT PRICE - MEASUREMENT AND PAYMENT

A. Pipe and Fittings:

1. Basis of Measurement: By the linear foot.
2. Basis of Payment: Includes hand trimming, excavation, trenching, piping and fittings, all valves and appurtenances not listed separately on the Bid Form, bedding, backfill, compaction, tracer wire, detectable warning tape, above ground pipe marker posts, concrete thrust restraints, mechanical joint restraints, connection to public utility water source (if not separately listed on Bid Form). Excavation requiring specialized equipment for rock removal, as defined in Section 31 23 18 - Rock Removal, will be paid for separately per Article 1.2 of same said Section 31 23 18. Backfill required to replace removed rock, whether imported or processed on-site to meet the project specifications, will be incidental to the cost of pipe installation. Similarly, soil cement (CLSM), if used, shall be considered incidental to the cost of the pipe installation.
3. The actual laboratory cost of compaction, concrete, and destructive HDPE joint testing shall be reimbursed to the Contractor, upon submittal of invoices. Work

performed by Contractor or Sub-Contractor related to such testing, or any other work performed by laboratory personnel outside of actual compaction, concrete, and HDPE joint testing, shall be considered incidental and shall not be reimbursable from testing allowance. Work shall be coordinated and directed by Engineer. Contractor shall pay for all failed tests.

4. The cost of work associated with hydrostatic pressure testing for main pipeline and wash crossings shall be paid via a separate bid item. The cost of work associated with hydrostatic pressure testing for all other facilities (including site piping) for which a separate bid item is not provided shall be considered incidental to their respective bid items.

5. The cost of work associated with disinfection and bacteriological testing for main pipeline and wash crossings shall be paid via a separate bid item. The cost of Contractor's work associated with disinfection and bacteriological testing for all other facilities (including site piping, tank, etc.) for which a separate bid item is not provided shall be considered incidental to their respective bid items.

   a. Laboratory costs associated with bacteriological testing shall be considered incidental and are not eligible for reimbursement under the testing allowance.

B. Cathodic Protection:

1. Basis of Measurement: Per each for valves and steel casings. Cathodic protection for metallic fittings or any other unlisted non-stainless metallic components within corrosive soil zones shall be considered incidental.

2. Basis of Payment: Includes cathodic protection design, installation, energizing, adjustment, testing and all materials not listed separately on the bid form.

1.3 REFERENCES

A. Contractor shall refer to the latest revision of all standards listed herein.

B. American Association of State Highway and Transportation Officials (AASHTO):

1. AASHTO T180 - Standard Specification for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop.

C. American Society of Mechanical Engineers (ASME):

1. ASME B16.1 - Cast Iron Pipe Flanges and Flanged Fittings.

2. ASME B16.5 - Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24 Metric/Inch Standard

D. American Society for Testing and Materials International (ASTM):

1. ASTM A36/A36M - Standard Specification for Carbon Structural Steel.

2. ASTM A53 - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.

3. ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.

4. ASTM A139 – Standard Specification for Electric Fusion (Arc) Welded Steel Pipe

5. ASTM A283 – Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates
6. ASTM A307 - Standard Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength.
7. ASTM F593 – Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs
8. ASTM F594 – Standard Specification for Stainless Steel Nuts.
9. ASTM A1011 – Standard Specification for Steel, sheet and strip, Hot Rolled, Carbon, Structural, High Strength Low Allow, High Strength Low Alloy with Improved Formability, and Ultra High Strength
10. ASTM A1018 – Standard Specification for Steel, Sheet and Strip, Heavy Thickness Coils, Hot Rolled, Carbon, Commercial, Drawing, Structural, High Strength Low Alloy, High Strength Low Allow with Improved Formability, and Ultra High Strength
11. ASTM B843 – Standard Specification for Magnesium Alloy Anodes for Cathodic Protection
12. ASTM D653 - Terminology Relating to Soil, Rock, and Contained Fluids.
13. ASTM D698 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft3 (600 kN-m/m3))
14. ASTM D1784 - Standard Specification for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds.
15. ASTM D1785 - Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120
16. ASTM D2152 - Test Method for Degree of Fusion of Extruded Poly (Vinyl Chloride) (PVC) Pipe and Molded Fittings by Acetone Immersion
17. ASTM D2467 – Standard Specification for Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80
18. ASTM D2487 - Classifications of Soils for Engineering Purposes (Unified Soil Classification System).
19. ASTM D2513 - Standard Specification for Polyethylene (PE) Gas Pressure Pipe, Tubing, and Fittings.
20. ASTM D2774 – Standard Practice for Underground Installation of Thermoplastic Pressure Piping
21. ASTM D3035 – Standard Specification for Polyethylene Plastic Pipe (DR PR) Based on Controlled Outside Diameter
22. ASTM D3350 - Standard Specification for Polyethylene Plastics Pipe and Fittings Materials
23. ASTM D3363 – Standard Test Method for Film Hardness by Pencil Test
24. ASTM D3139 - Standard Specification for Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals.

25. ASTM D4752 – Standard Practice for Measuring MEK Resistance of Ethyl Silicate Zinc Rich Primers by Solvent Rub ASTM D638 – Standard Test Method for Tensile Properties of Plastics
26. ASTM D6938 - Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).
27. ASTM E165 – Standard Practice for Liquid Penetrant Examination for General Industry
28. ASTM F477 - Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe.
29. ASTM F714 - Standard Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter
30. ASTM F1057 - Standard Practice for Estimating the Quality of Extruded Poly (Vinyl Chloride) (PVC) Pipe by the Heat Reversion Technique
31. ASTM F2164 – Standard Practice for Field Leak Testing of Polyethylene Pressure Piping Systems Using Hydrostatic Pressure
32. ASTM F2620 – Standard Practice for Heat Fusion Joining of Polyethylene Pipe and Fittings
33. ASTM F2634 - Standard Test Method for Laboratory Testing of Polyethylene (PE) Butt Fusion Joints using Tensile-Impact Method

E. American Water Works Association (AWWA):

1. AWWA C104 - ANSI Standard for Cement Mortar Lining for Ductile-Iron Pipe and Fittings for Water.
2. AWWA C105 - ANSI Standard for Polyethylene Encasement for Ductile-Iron Pipe Systems.
3. AWWA C110/ ANSI A21.10 - ANSI Standard for Ductile-Iron and Gray-Iron Fittings, 3 In. through 48 In. (76 mm through 1,219 mm), for Water.
4. AWWA C111/ ANSI A21.11 - ANSI Standard for Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings
5. AWWA C115 - ANSI Standard for Flanged Ductile-Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges.
6. AWWA C116 – Protective Fusion-Bonded Epoxy Coatings for the Interior and Exterior Surfaces of Ductile-Iron and Gray-Iron Fittings for Water Supply Service
7. AWWA C151 - ANSI Standard for Ductile-Iron Pipe, Centrifugally Cast, for Water or Other Liquids.
8. AWWA C153 - ANSI Standard for Ductile-Iron Compact Fittings for Water Service.
9. AWWA C200 - Steel Water Pipe 6 In. (150 mm) and Larger.
10. AWWA C206 - Field Welding of Steel Water Pipe.
11. AWWA C207 - Steel Pipe Flanges for Waterworks Service - Sizes 4 In. through 144 In. (100 mm through 3,600 mm).

12. AWWA C208 - Dimensions for Fabricated Steel Water Pipe Fittings.
13. AWWA C209 - Cold-Applied Tape Coatings for the Exterior of Special Sections, Connections, and Fittings for Steel Water Pipelines.
14. AWWA C210 – Standard for Liquid-Epoxy Coating Systems for the Interior and Exterior of Steel Water Pipelines
15. AWWA C213 - Fusion-Bonded Epoxy Coating for the Interior and Exterior of Steel Water Pipelines.
16. AWWA C219 – Standard for Bolted, Sleeve-Type Couplings for Plain-End Pipe
17. AWWA C600 - Installation of Ductile-Iron Water Mains and their Appurtenances.
18. AWWA C605 - Underground Installation of Polyvinyl Chloride PVC Pressure Pipe and Fittings for Water.
19. AWWA C900 - Polyvinyl Chloride (PVC) Pressure Pipe, and Fabricated Fittings, 4 In. through 12 In. (100 mm through 300 mm), for Water Distribution.
20. AWWA C901 - Polyethylene Pressure Pipe and Tubing, 1/2 In. through 3 In. (13 mm through 76 mm), for Water Service.
21. AWWA C905 - Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 14 In. through 48 In. (350 mm through 1,200 mm), for Water Transmission and Distribution.
22. AWWA C906 - Polyethylene Pressure Pipe and Fittings, 4 In. through 63 In. (100 mm through 1,575 mm), for Water Distribution and Transmission).
23. AWWA M11 – Steel Pipe: A Guide for Design and Installation
24. AWWA M23 – PVC Pipe – Design and Installation
25. AWWA M55 – HDPE Pipe: Design and Installation

F. NACE International (NACE)

1. SP0169 – Control of External Corrosion on Underground or Submerged Metallic Piping Systems
2. TM0497 – Measurement Techniques Related to Criteria for Cathodic Protection on Underground or Submerged Metallic Piping Systems
3. SP0274 – High-Voltage Electrical Inspection of Pipeline Coatings Prior to Installation.

G. Manufacturer’s Standardization Society of the Valve and Fittings Industry:

1. MSS SP-60 - Connecting Flange Joint between Tapping Sleeves and Tapping Valves.

H. Society for Protective Coatings:

1. SSPC-SP5 White Metal Blast Cleaning

I. National Fire Protection Agency

1. NFPA 24 - Standard for the Installation of Private Fire Service Mains and Their Appurtenances.

J. NSF International Standard / American National Standard (ANSI)

1. NSF/ANSI 61 – Drinking Water System Components – Health Effects.

K. National Association of Pipe Fabricators

1. NAPF 500 – Surface Preparation Standard for Ductile Iron Pipe and Fittings in Exposed Locations Receiving Special External Coatings and/or Special Internal Linings.

L. American Welding Society

1. AWS D1.1 – Structural Welding Code

1.4 SUBMITTALS

A. Section 01 00 00 - Submittal Procedures: Requirements for submittals.

B. Product Data: Submit data on pipe materials, pipe fittings, and accessories.

C. Manufacturer's Certificate: Certify Products meet or exceed specified requirements.

D. In addition to the submittal requirements listed above, Contractor shall also submit:

1. Shop drawings for any custom-fabricated steel fittings which clearly show compliance with AWWA M11, AWWA C207 and AWWA C208. Include design calculations, as applicable.

2. Submittal for all coatings which demonstrate compliance with relevant AWWA and NACE standards.

3. Design calculations, drawings and material data sheets for cathodic protection and monitoring systems. Include assumptions and basis for design. Include approximate locations of anodes, test stations and isolation kits. Include copy of cathodic protection specialist's NACE certification.

4. As-built drawings and any Contractor-provided survey data. Refer to Sections 01 00 00 – Basic Requirements and 02 21 13 - Surveying.

5. Shop drawings, with dimensions, of HDPE sweeps.

1.5 CLOSEOUT SUBMITTALS

A. Section 01 00 00 - Execution Requirements: Requirements for submittals.

B. Project Record Documents: Refer to Sections 01 00 00 – Basic Requirements and 02 21 13 – Surveying.

1. All fusible HDPE joint fusion documentation and fusion machine data logs shall be submitted to Engineer with project record documents, in addition to ongoing data log and analysis submittals during construction process.

C. Identify and describe unexpected variations to subsoil conditions or discovery of uncharted utilities.

1.6 QUALITY ASSURANCE

A. Perform Work in accordance with the most recent edition of New Mexico Standard Specifications for Public Works Construction, with latest revisions.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Section 01 00 00 - Product Requirements: Requirements for transporting, handling, storing, and protecting products.

B. Block individual and stockpiled pipe lengths to prevent moving.

C. Do not place pipe or pipe materials on private property without prior authorization, or in areas obstructing pedestrian or vehicular traffic.

D. Store PVC materials out of sunlight. Contractor shall, at Contractor's expense, provide and maintain tarps, temporary shelters, or other such measures as necessary to protect PVC materials from sunlight. Such tarps or shelters must be adequately vented to prevent excess heat accumulation

1. Any PVC materials judged by the Engineer to be sun-damaged, including tan to brown discoloration, blistering, roughening or cracking of surface, or embrittlement, prior to installation shall be rejected.

E. Coated pipe shall be shipped on bunks and secured with nylon belt tie down straps or padded banding over braces, and shall be stored on padded skids or other suitable means to prevent damage to coating.

F. Coated pipe and other components shall be handled with wide belt slings, padded forks or other means to prevent damage to coating. Chains, cables or other equipment likely to damage coating or pipe shall not be used.

G. PVC pipe shall be bundled or stacked throughout the shipping, storage and handling process in accordance with AWWA M23 and pipe supplier's recommendations, whichever is most stringent. Excessive bundling or stacking that results in bends, kinks, gashes or uncorrectable ovality shall be rejected. Transport and handle pipe in accordance with AWWA M23 and pipe supplier's recommendations, whichever is most stringent. Off-loading devices such as chains, wire rope, chokers, or other pipe handling implements that may scratch, nick, cut, or gouge the pipe are strictly prohibited.

1. Any pipe showing a crack or which has received a blow that may have caused an incident fracture, even though no fracture can be seen, shall be rejected.

2. Any pipe with a scratch or gouge greater than 10% of the wall thickness will be rejected.

H. HDPE pipe shall be bundled or stacked throughout the shipping, storage and handling process in accordance with AWWA M55, PPI and/or manufacturer's recommendations, whichever is most stringent. Excessive bundling or stacking that results in bends, kinks or uncorrectable ovality shall be rejected. Transport and handle pipe in accordance with AWWA, PPI and/or manufacturer's recommendations, whichever is most stringent.

I. Prior to shipment and again prior to installation, all materials shall be visually inspected for damage, including coatings and surfaces. Any damaged materials shall be repaired to original standards or replaced.

1.8 FIELD MEASUREMENTS

A. Verify field measurements prior to fabrication.

PART 2 PRODUCTS

2.1 WATER PIPING AND FITTINGS

A. Polyvinyl Chloride (PVC):

1. All PVC pipe, shall conform to AWWA C900 and AWWA C905, on all PVC pipe 4” diameter and greater, and ASTM D1785, Schedule 80, on all PVC pipe less than 4” diameter. Testing shall be in accordance with the referenced AWWA standard for all pipe types.

2. All piping shall be made from PVC compound conforming to cell classification 12454 per ASTM D1784.

3. Pipe shall be homogeneous throughout and be free of visible cracks, holes, foreign material, blisters, or other visible deleterious faults.

4. Pipe shall be blue in color for potable water use.

5. Nominal laying length:

   a. Jointed PVC pipe: 20 feet.

6. Gasketed Joints:

   a. Joints per ASTM D3139.

   b. Use rubber gaskets manufactured and tested in accordance with ASTM F477.

   c. Within 200’ radius of petroleum line crossings or where otherwise indicated on Drawings, use petroleum-resistant gaskets in accordance with ASTM F477.

7. Fittings:

   a. Ductile iron on all PVC pipe 4” diameter and greater.
      1) Refer to specifications for ductile iron fittings in this section, below.

   b. All PVC pipe and fittings less than 4” diameter shall be solvent welded Schedule 80.

   c. Solvent-weld joints are not permitted on pipe 4” diameter and greater.

8. Mechanical Joint Restraints:

   a. Refer to specifications for ductile iron joint restraints in this section, below.

9. Mechanical bell restraint harnesses:

   a. Shall be used for joint restraint within casings as noted on Drawings.
      1) Mechanical bell restraints shall be “EBAA Iron, Megalug®” Series 2800, or approved equal.
      2) Wedge assemblies and glands shall be fusion bonded epoxy coating in accordance with AWWA C116 or Mega-Bond coated, interior and exterior.

3) Stainless steel 304 bolts, nuts and washers for all buried applications, provided by manufacturer especially for use with their respective components. If fitting manufacturer cannot supply stainless steel bolts contractor may provide bolts from another source; however, contractor is solely responsible to ensure fit and compatibility of said bolts.

b. Shall not be allowed for uncased bury. PVC pipe joint restraints shall be provided using thrust blocking.

B. Ductile Iron Pipe, Joints, and Fittings:

1. Manufacturers:

a. US Pipe

b. American Pipe

c. Substitutions: Approved Equal

2. Ductile iron pipe:

a. To be used where specifically identified as ductile iron on the drawings. Do not use ductile iron pipe at any other location without Engineer's prior written approval.

b. Pipe Class: AWWA C151, for nominal thickness, rated water working pressure and maximum depth of cover.

c. 350 psi working pressure.

d. Cement Mortar Lining: AWWA C104, standard thickness.

e. Exterior coating:

1) Buried service (site piping only): Bituminous coating, per AWWA C151.

3. Fittings: Ductile iron.

a. Compact MJ fittings conforming to AWWA C153 or AWWA C110, unless otherwise noted on Drawings.

b. Flanged fittings shall conform to AWWA C110. Do not use flanged fittings for buried installations unless otherwise noted on Drawings.

1) Contractor responsible to ensure that all mating flanges have compatible diameters, bolt sizes and drill patterns. Overdrill bolt holes as necessary, provided such overdrlling is within manufacturer's recommended tolerances.

c. Pressure rating of MJ joints, fittings and gaskets shall be at least 350 psi, unless otherwise noted on the Drawings.

d. Pressure rating of flanged fittings and gaskets shall at least match that of the attached pipe, unless otherwise noted on the Drawings.

e. Marked with pressure rating, nominal diameter of opening, manufacturers' identification, country where cast, and degree of bend.

f. Coatings:

1) Main line fittings, butterfly valve, flush valve, and air valve assembly components (including spools):

a) All exposed interior and exterior surfaces shall be coated with fusion-bonded epoxy in accordance with AWWA C116.

b) All coatings shall be applied in strict accordance with coating manufacturer's recommendations.

c) All fusion-bonded epoxy coatings shall be holiday-free.

2) Site piping fittings for use on PVC and DIP (for use within tank site only):

a) Exterior: Bituminous Coating: AWWA C110.

b) Interior: Cement Mortar Lining: AWWA C104, standard thickness.

c) Encasement: Encase in polyethylene as described in this section.

g. Provide sacrificial anode cathodic protection where indicated in this Section.

4. Joints:

a. Mechanical and Push-On Joints: AWWA C111. Only use where expressly allowed on the Drawings. No DI pipe joints shall be allowed underneath or within 5 feet of any structure.

1) All push-on joints shall be fully restrained

2) TR Flex restrained pipe joints

3) TR Flex lockers shall be ductile iron. Redwood or other materials shall not be allowed.

b. Flanged Joints: AWWA C115; ASME B16.1.

5. Mechanical Joint Restraints:

a. Mechanical joint restraints for all fittings and appurtenances, unless otherwise noted on Drawings.

b. Mechanical joint restraints shall be "EBAA Iron, Megalug®" Series 2000PV and 2200, Romac Romagrip, Smith-Blair Cam-Lock, or approved equal, for all pipe 4" diameter and greater.

c. Wedge assemblies and glands shall be fusion bonded epoxy coating in accordance with AWWA C116 or Mega-Bond coated, interior and exterior.

d. Provide sacrificial anode cathodic protection where indicated in this Section.

e. Stainless steel 304 bolts, nuts and washers for all buried applications, provided by manufacturer especially for use with their respective components. If fitting manufacturer cannot supply stainless steel bolts contractor may provide bolts from another source; however, contractor is solely responsible to ensure fit and compatibility of said bolts.

6. Jackets:

a. AWWA C105 polyethylene jacket, Installation Method "A".

b. Double-wrap all ductile iron components, unless they are cathodically protected.

c. Inner PE jacket shall be V-Bio enhanced, minimum thickness: 8 mil

d. Outer PE jacket shall be standard polyethylene, minimum thickness: 8 mil

e. Secure PE jackets with ultra-high molecular weight (UHMW) polyethylene film tape, 10 mil thickness.
1) Do not use duct tape to tape the PE jackets.

f. Do not use polyethylene encasement on ductile iron fittings with cathodic protection.

C. Steel Pipe and Fittings:

1. Pipe fabrication:

a. For pipe 26" diameter and greater, fabricate arc-welded spiral seam steel pipe: ASTM A139, Grade B, C, D or E. For pipe 26" diameter or less, fabricate pipe per ASTM A-53 B.

b. Fabricated in accordance with AWWA C200, except:

1) Steel plate: ASTM A283, Grade C or D, or ASTM A36.

2) Steel sheet: ASTM A1011, Designation SS, Grade 40, 45 or 50; or ASTM A1018, Designation SS, Grade 40.

3) Standard wall thickness, unless otherwise indicated on Drawings.

2. Fittings and Special Sections:

a. Steel for fittings: ASTM A283, Grade C or D, or ASTM A36 for carbon steel.

b. Welding: Per AWS D1.1. All welding must be completed prior to application of lining and coatings, unless otherwise permitted by the Engineer. In no case shall any welding damage lining or coatings.

c. Dimensions in accordance with AWWA C208.

d. Custom fabricated fittings shall be designed and fabricated in accordance with AWWA M11, with outlet reinforcements per AWWA M11. All other standards and specifications for steel, welds, coatings, flanges and dimensions of component fittings provided herein shall apply equally to custom fabricated fittings.

e. No custom-made fittings shall be used without prior written approval by the Engineer.

3. Coatings: Interior and exterior surfaces of all non-stainless steel pipe and fittings shall be coated as follows:

   a. Interior and exterior fusion bonded epoxy coated in accordance with AWWA C213.

      1) For small diameter pipes, where it is not practical to apply fusion bonded epoxy coatings, the use of liquid epoxy coatings in accordance with AWWA C210 may be considered in lieu of fusion-bonded epoxy for interior surfaces, with prior approval by the Engineer. The burden shall be upon to Contractor to submit sufficient data and obtain Engineer's approval for such substitutions.

   b. All coatings shall be NSF 61-approved.

   c. All surfaces shall be ground smooth. All weld splatter and other defects shall be removed prior to blasting.

   d. Surface preparation shall conform to SSPC-SP5 White Blast Clean with surface profile of 2.0 to 3.0 mils.

   e. Coating thickness for both interior and exterior shall be not less than 12.0 mils DFT and shall not exceed coating manufacturer's recommended maximum thickness.

   f. All wetted surfaces of pipe interior shall be coated. All exposed surfaces of pipe exterior shall be coated.

   g. Do not apply coating to mating surfaces of flanges.

   h. Typical water temperature: Less than 140 degrees Fahrenheit.

   i. Minimum field adhesion: 700 psi.

4. Additional Coatings:

   a. Exterior surfaces of all buried non-stainless steel pipe and welded fittings shall include cold-applied tape coating, manufactured and installed in accordance with AWWA C209, applied with a minimum overlap width of 1-inch and a total coating thickness shall be a minimum of 80 mils. Such tape coating shall be applied in addition to fusion-bonded epoxy coatings specified above.

5. Flanges:

   a. Flange class as noted on Drawings.

   b. Pressure rating of flanges and gaskets shall meet or exceed surge pressure rating of attached pipe.

   c. Coatings and linings shall be continuous to the ends of pipe and backs of flanges.

   d. Do not apply coatings to mating surfaces of flanges.

e. Gaskets shall be ring-type, per AWWA C207, unless the flanged connection is between PVC and steel, in which case full face type gaskets with outer diameter equal to that of the flange shall be used.

f. Retainers shall be fabricated of phenolic or other suitable material as recommended by manufacturer and conforming to NSF 61, with minimum thickness of 1/8 inch and minimum dielectric strength of 500 volts/mil.

g. Nitrile sealing rings.

h. Steel washers shall be 1/8-inch thick.

i. All bolts, nuts and washers shall be stainless steel 304, unless otherwise noted. All bolts shall be provided by manufacturer especially for use with their respective fittings. If manufacturer cannot supply stainless steel bolts, Contractor may provide bolts from another source; however, Contractor is solely responsible to ensure fit and compatibility of said bolts.

j. Bolt shall be long enough to protrude through the assembled nut at least two threads but not more than ½-inch.

k. Contractor is responsible to ensure that all pipe flanges that connect to valve body flanges have the same dimensions, drill pattern, bolt hole diameter and equal or higher pressure rating as the valves to which they are connected.

1) Overdrill bolt holes as necessary, provided such overdrilling is within manufacturer's recommended tolerances.

l. Contractor shall be responsible to verify compatibility of all flange bolt patterns prior to purchasing materials and shall notify the Engineer in the event that alternate bolt patterns are required to mate flanges.

6. Field Welding Materials:

a. Pipe: AWWA C206.

7. Stainless Steel Pipe and Fittings

a. Use where called-out on Drawings as Stainless Steel

b. Stainless Steel 304

c. Pressure rating: Not less than 300 psi Cold Working Pressure

D. Polyethylene Pipe:

1. AWWA C901-08 and ASTM D3035 for sizes up to 3" diameter; AWWA C906 (as applicable) and ASTM F714 for sizes 4" diameter and above.

2. Each production lot of pipe shall be tested for melt index, density, percent carbon, dimensions and ring tensile strength.

3. Polyethylene pipe and fittings shall be PE 4710 high-density polyethylene meeting ASTM D3350 cell classification PE445574C. The material shall be listed and approved for potable water in accordance with NSF Standard 61.

4. Not less than four permanent co-extruded, equally spaced, blue color stripes in outside surface of pipe.
5. Molded fittings constructed of HDPE PE 4710 in accordance with ASTM F714.
6. Fabricated fittings shall be made by heat fusion joining specially machined shapes cut from pipe, polyethylene sheet stock or molded fittings; rated for internal pressure service at least equal to the full service pressure rating of the mating pipe; and tested in accordance with AWWA C906.
    a. HDPE flange and mechanical joint adaptors shall be rated to the same pressure as the mating pipe. Steel slip-on flanges used in conjunction with HDPE flange adaptors shall comply with all specifications for steel flanges set forth in this section.
7. Polyethylene flange or MJ adapters made with sufficient through-bore to be clamped in a butt fusion-joining machine without use of a stub-end holder, as per pipe manufacturer's instructions.
8. All HDPE fabricated MJ adapters shall have stainless steel stiffeners.
9. HDPE pipe and fittings shall have a working pressure (as set forth in ASTM F714) of not less than 200 psi for DR 11, not less than 160 psi for DR 13.5, not less than 138 psi for DR 15.5, and not less than 125 psi for DR 17, with a recurring surge pressure allowance (total pressure) of 1.50 times working pressure and occasional surge allowance (total pressure) of 2.00 times working pressure (surge allowances shall be based on AWWA C906 and/or AWWA M55).
10. Nominal sizes indicated on Drawings for both pipe and fittings denote iron pipe size (IPS) unless otherwise noted.
11. All HDPE pipe and fittings shall be manufactured of PPI listed materials.
12. Pre-fabricated HDPE mitered bends and other fittings shall have internal weld bead completely removed prior to installation, using approved method for weld bead removal.

2.2 TAPPING SLEEVES AND SADDLES,

A. Tapping Sleeves:

1. Manufacturers:
    a. Mueller Co.
    b. Romac Industries, Inc
    c. JCM Industries
    d. Ford Meter Box Company, Inc
    e. Smith-Blair, Inc
    f. Substitutions: Approved equal.
2. Tapping sleeves shall be used for all taps larger than 2-inches.

3. Shall be fusion-bonded epoxy-coated steel sleeves.
4. All sleeves shall be specifically designed for use on the type of pipe that is being tapped.
5. All bands, straps, bolts, nuts and washers shall be SS 304. All bolts shall be provided by manufacturer especially for use with their respective components.
6. Sleeve Working pressure rating: 250 psi
7. Tapping sleeves shall be used on unrestrained bell-and-spigot PVC, and DI pipe only. Tapping sleeves shall not be used on HDPE.
8. Tapped Outlet: FNPT or MJ, as indicated on Drawings
9. Tapping sleeves within “Corrosive Soil Areas” as designated on the Drawings and this Section shall require cathodic protection.
10. All pipe taps shall be made with an engineer approved tapping machine.
11. Threadolets, where called for on Drawings, shall be welded to the pipe, ground, and blasted (if possible) prior to applying fusion-bonded epoxy coating to the pipe.

B. Tapping Saddles:

1. Manufacturers:
   a. Romac Industries, Inc. Model 202-NS
   b. Substitutions: Approved equal.
2. Tapping saddles shall be used for taps 2-inches or smaller.
3. Nylon coated ductile iron tapping saddles with stainless steel dual compression straps.
4. All saddles shall be specifically designed for use on the type of pipe that is being tapped.
5. All bands, straps, bolts, nuts and washers shall be SS 304. All bolts shall be provided by manufacturer especially for use with their respective components.
6. Saddle Working pressure rating: 350 psi.
7. Tapping saddles shall be used on unrestrained bell-and-spigot PVC, and DI pipe only. Tapping sladdles shall not be used on HDPE.
8. Tapped Outlet: FNPT or MJ, as indicated on Drawings
9. All pipe taps shall be made with an engineer approved tapping machine.
10. Threadolets, where called for on Drawings, shall be welded to the pipe, ground, and blasted (if possible) prior to applying fusion-bonded epoxy coating to the pipe.

2.3 CORROSION PROTECTION AND MONITORING SYSTEMS

A. Refer to Cathodic Protection Specification.

2.4 UNDERGROUND PIPE MARKERS

A. Furnish materials in accordance with the most recent edition of New Mexico Standard Specifications for Public Works Construction, with latest revisions.

B. Tracer Wire: 12 AWG, Solid Copper, Single Conductor, 600V, UF-XHHW wire or equal, for underground installation.

C. Metal-backed detectable water marker tape: Bright colored, metallized for detection by above-ground metal detector, continuously printed, minimum 6 inches wide by 4-mil thick, manufactured for direct burial service, imprinted with "BURIED WATER SERVICE" in large letters.

2.5 ABOVE-GROUND PIPE MARKERS

A. Carsonite marker posts, blue, with Navajo Tribal Utility Authority (NTUA) decals. Decals to be specified by NTUA and provided by the Contractor. Place markers as specified on the Drawings.

2.6 PIPE SUPPORTS AND ANCHORING

A. Metal for pipe support brackets: ASTM A123/A123M, galvanized structural steel thoroughly coated with bituminous paint.

B. Metal tie rods and clamps or lugs: Galvanized steel sized in accordance with NFPA 24 thoroughly coated with bituminous paint.

2.7 CASING SPACERS

A. Polyethylene Casing Spacer

B. Two part or multi segmented

C. Stainless steel 304 bolts, nuts and washers. All bolts shall be provided by the fitting manufacturer especially for use with their respective components.

2.8 BEDDING AND BACKFILL MATERIALS

A. As specified in Section 31 23 23.

2.9 ACCESSORIES

A. Concrete for Thrust Restraints (where applicable): Conform to Section 03 30 00, with minimum compressive strength of 3,000 psi.

B. Steel rods, bolt, lugs and brackets

1. For applications not in contact with soil: ASTM A36/A36M or ASTM A307 carbon steel.

2. For buried applications: Stainless steel 304.

2.10 SOURCE QUALITY CONTROL

A. Pipe:

1. Polyvinyl chloride (PVC): Factory test all PVC pipe in accordance with AWWA C900 or AWWA C905, as applicable.

2. Ductile iron: Factory test in accordance with AWWA C151 and AWWA C104.

3. Steel: Factory test in accordance with AWWA C200, ASTM A53, or ASTM A139.

   a. Hydrostatic test: Factory test per AWWA C200 to stress steel to 23,000 psi for at least 15 minutes, or longer as needed to allow for thorough inspection. Conduct test after all formed and welded ends have been completed and attached.

   b. Repair defects and re-test prior to applying lining and coating.

4. HDPE: Factory test all HDPE pipe in accordance with AWWA C901 or AWWA C906, as applicable.

   a. ASTM F2634 testing of HDPE factory test fusions, will be required prior to installation. The testing reports must share common, unique identifiers with the shipping bills, in order to establish that 100% of pieces shipped pertain to the same batches that were tested and that the testing reports are truly representative of the actual pieces shipped.

B. Fittings:

1. Ductile iron (DI): Factory test in accordance with AWWA C153 and AWWA C110, as applicable.

2. Steel:

   a. Steel plate fittings: Factory test fittings fabricated from steel plate to stress steel under hydrostatic pressure to 23,000 psi for at least 15 minutes, or longer as needed to allow for thorough inspection.

   b. Steel pipe fittings: Fittings fabricated from tested steel pipe do not require hydrostatic testing if girth butt welds are complete penetration welds. Perform dye penetrant test on welds in accordance with ASTM E165.

   c. Pipe should conform to ASTM A53, ASTM A139 or AWWA C200.

   d. Remove all defects disclosed during testing, re-weld and re-test the fitting.

3. HDPE: Factory test all HDPE fittings in accordance with AWWA C906.

C. Coatings:

1. All fusion-bonded epoxy coatings shall be holiday-free.

2. Cure testing for fusion bonded or liquid epoxy coatings: ASTM D4752 and ASTM D3363, Every 1000 sq. ft. of epoxy coating.

3. Holiday testing for epoxy and cold-applied tape coatings:

   a. All fusion-bonded epoxy coatings and cold-applied tape coatings on all pipes and fittings shall be holiday tested prior to installation, at no additional cost to the Owner.

   b. Perform testing in accordance with NACE Standard SP0274, using electrical holiday tester. Use test voltage below:

Total Coating Thickness (Mils)	Test Voltage (Volts)
20 or less	6000
30	7500
50	9000
70	11500
80 or more	12000

c. All holidays shall be repaired and re-tested, at no additional cost to the Owner.

4. Touch up and repair of Fusion Bonded Epoxy Coatings

a. Applies to all FBE coated valves for field repair of minor holidays, scratches, breaks or other damage to FBE coating.

b. Does not include repair or touch up of systemic or large area holidays in FBE coating. Repair of systematic holidays or damaged areas larger than three (3) sq. in. will require the damaged coating be ground off and the valve be newly shop-coated.

c. Materials and application:

1) NSF/ ANSI 61 certified, two-part, 100% solids, liquid epoxy coating meeting the requirements of AWWA C210.

a) Manufacturer: 3M Scotchkote Epoxy Coating 323, OAE.

b) If temperature is below 55 degrees Fahrenheit, the metal substrate shall be pre-heated in accordance with coating manufacturer’s recommendations prior to applying the coating.

d. Prepare surface and apply per coating manufacturer’s instructions for use as a field repair material.

D. All shop welding shall be performed by certified welders.

E. All shop welds shall be tested by ultrasonic or radiographic methods in accordance with AWS D1.1.

F. Engineer reserves right to require additional holiday testing of any and all coated components that are suspected of having holidays in the field prior to installation. Costs of failed tests shall be borne by the Contractor; costs of passed additional tests shall be reimbursable from the Testing Allowance.

2.11 SOURCE QUALITY ASSURANCE

A. Acceptance of materials will be based on compliance with relevant AWWA, ASTM and other relevant standards. Materials must pass all relevant tests prior to acceptance.

B. Compliance with standards will be determined based on:

1. Documentation of factory testing. Such tests must be completed in accordance with relevant AWWA, ASTM, AWS or other applicable standards. All testing

must be completed and documented by qualified personnel. The Engineer reserves the right to observe the testing while in process and to demand all testing documentation at any time.

2. Inspection by the Engineer. The Engineer reserves the right to inspect all materials both during and after manufacture.

C. The Engineer reserves the right to demand evidence of certification of all personnel performing shop or field welding on steel pipe and fittings.

PART 3 EXECUTION

3.1 EXAMINATION

A. Section 01 00 00 - Administrative Requirements: Verification of existing conditions before starting work.

B. Verify existing utility water main size, location, and invert, are as indicated on Drawings.

3.2 PREPARATION

A. Pre-Construction Site Photos:

1. Prior to beginning construction, take photographs or videotape along centerline of proposed pipe trench. The photos or video must include coverage of all areas and adjacent features that may potentially be impacted by the impending construction work.

2. Photographs shall be taken at a minimum of one for each 200 feet of pipe trench. Videos shall cover a maximum of 2,000 feet per video file.

3. Video or photographs shall be taken after Station markers or stakes are in place for the section of pipeline or site(s) to be recorded. Video or photos must include sufficient close-ups of stakes to clearly indicate the location.

4. Prior to groundbreaking on any section of pipeline or site work, video or photographs must be submitted to the Engineer for review and approved. Video or photo documentation must be approved as sufficient by Engineer before groundbreaking may proceed.

5. Show station markers, mailboxes, fences, structures, driveways, signs, culverts, and other existing site features.

6. Include project description, applicable stations or sites, and date taken in the file name of every photograph or video, using the following filename convention: "<project name>_<begin station>_to_<end station>_<date>".

7. Video or photo submittals may be rejected because of failure to include or document any of the items above, a lack of visual or audio clarity, or for any other deficiency that prevents the Owner / Engineer from easily viewing and documenting the pre-construction conditions of the pipeline and sites.

8. If using video, Contractor must submit two (2) copies of the video documentation on DVD format as part of the submittal process. If using photographs, Contractor must submit 2 copies of digital photograph files in DVD format as part of the submittal process.

B. Construction staking:

1. Refer to Section 02 21 13 – Surveying.

C. Restricted Areas and Culturally Sensitive Areas:

1. Contractor shall notify Engineer prior to work within 100 feet of any restricted area as designated on the Drawings; refer to Section 01 00 00.

2. The Owner's Surveyor will erect barricades at the limits of any truncated temporary construction easements. The Owner's Archaeologist will flag culturally sensitive sites as designated on the Drawings.

3. Contractor shall maintain all flags, stakes and barricades in place until the end of construction. Contractor shall notify Engineer in the event of damage or removal of said markers. Re-marking due to negligence by Contractor shall be subject to charge-backs to the Contractor.

4. No work shall be performed within 100 feet of any restricted area or truncated TCE unless barricades and/or flags are up.

5. No work shall be performed within 100 feet of any restricted area designated on the Drawings as requiring archaeological monitoring unless the Owner's archaeologist is physically present at the site.

3.3 TRENCHING

A. In accordance with Section 31 23 17.

3.4 BEDDING

A. In accordance with Section 31 23 23.

3.5 INSTALLATION – PIPE

A. Install bell-and-spigot PVC pipe in accordance with AWWA C605, AWWA M23 and pipe manufacturer's instructions, whichever is most stringent.

1. Use only lubricants supplied by the pipe manufacturer and apply to both bell and spigot ends of the joint, in accordance with manufacturer's recommendations.

2. Clean the gasket, bell, groove and spigot immediately prior to connecting pipe joints.

3. Do not over-insert pipe joints. Any over-inserted pipe joints shall be removed and the pipe bell and gasket inspected for damage. Any damaged bells or gaskets shall be discarded and replaced.

4. Cut pipe ends square, ream pipe and tube ends to full pipe diameter, remove burrs. Use only equipment specifically designed for pipe cutting. The use of chisels or hand saws will not be permitted. Grind edges smooth with beveled end for push-on connections.

B. Install ductile iron piping and fittings according to AWWA C600.

1. Encase all ductile iron pipe and fittings that are not cathodically protected in polyethylene, per AWWA C105, Method "A".

a. Use two (2) separate polyethylene jackets.

1) Inner jacket: V-bio enhanced polyethylene

2) Outer jacket: standard polyethylene

b. No tears, cuts, rips or other breaks in the polyethylene encasement shall be acceptable. No dirt, water or debris inside the encasement shall be acceptable.

c. When installing ductile iron pipe floor penetrations under buildings and concrete slabs, bring both layers of polyethylene into the slab inside the roof felt isolation joint. Trim and tape the PE at the mid-point of the slab thickness (e.g. 6” below the floor for a 12” slab). Wrap two layers of 30# roof felt outside both layers of polyethylene, extending 4” above and 4” below the slab. Trim the felt to 2” above the floor and seal with silicone. Extend PE encasement to PVC transition beyond building foundation.

d. Do not polyethylene encase any ductile iron fitting that has cathodic protection.

e. Use only 10-mil UHMW polyethylene film to tape the PE jackets. Do not use duct tape.

2. All push-on joints, where allowed on Drawings, shall be installed using TR Flex restrained joints. Install restrained joints in accordance with manufacturer’s recommendations.

C. Install steel pipe in accordance with AWWA M11. Field weld and test steel pipe, as needed, in accordance with AWWA C206, except as follows:

1. Test field welds by ultrasonic or radiographic method, in accordance with AWS D1.1.

2. Do not field weld pipe without permission from the Engineer.

Any damaged shop-applied coatings shall be repaired in accordance with this Section. In the event, that field repair is required due to damage of shop-applied coating, Contractor shall notify Engineer prior to making the repair.

D. Install HDPE pipe in accordance with ASTM D2774 and AWWA M-55.

E. Install cathodic protection for buried ferrous pipe, fittings and valves as indicated in the Corrosion Protection and Monitoring Systems provisions of this Section.

1. All buried steel and ductile iron pipe, whether cathodically protected or not, shall be joint bonded and connected to corrosion monitoring stations in accordance with the Corrosion Protection and Monitoring Systems provisions of this Section.

F. Handle and assemble pipe in accordance with manufacturer’s instructions and as indicated on Drawings. Inspect each pipe and fitting prior to lowering into trench to ensure there is no damage to the pipe, fitting or coatings. Repair any damage prior to installation. Clean ends of pipe and remove foreign material from inside of pipe and fittings.

G. Maintain 10 ft horizontal separation of water main from sewer piping in accordance with local code.

H. Centering and straightness of pipe:

1. Lay PVC and DI pipe in straight line and center pipe within trench. Re-lay pipe that is out of alignment.

2. Center HDPE pipe within the trench to the extent possible. HDPE pipe shall be allowed to “snake” laterally within the trench, provided that:

a. Such lateral deflection remains within manufacturer’s recommended limits

b. Minimum clearances between the pipe and trench wall are met

c. Adequate side clearance is provided on both sides of the pipe to allow for placement of soil cement slurry or placement and compaction of embedment material, and to eliminate voids in the pipe haunch area

In the event that minimum side clearances are not met and/or Contractor is unable to achieve required embedment specifications, the Contractor shall either straighten out the pipe and/or widen the trench as necessary to meet embedment specifications at no additional cost to the Owner.

I. Horizontal and vertical pipe bending, angles and joint deflections

1. All ells shall be one of the following standard angles: 11.25, 22.5, 45, 60 or 90 degrees. No other ell angles shall be allowed.

2. Actual horizontal and vertical angles required in the field shall be accomplished by a combination of allowable DI ells and/or pipe deflection (i.e. pipe bending or joint deflection, as specified below).

a. Horizontal bends:
1) At most locations, the plan and profile sheets show horizontal bends without specifying whether the horizontal bend is to be accomplished by DI ells, or joint deflection of jointed PVC pipe. At such locations, the method of bending is at Contractor’s option, provided all design requirements set forth in the Drawings and Specifications are met.
2) Install thrust block at horizonal ells per the construction drawings.
3) If Contractor chooses to install DI ell at a location that is not included on the thrust block and anchor wall summary of the drawings, prior to DI ell installation Contractor will submit proposed ell location and type to Engineer. Engineer will determine the required thrust block size to be constructed by Contractor.

b. Vertical bends:
1) Vertical bends shall be completed by joint deflection of jointed PVC.
2) Installation of vertical DI ells shall not be allowed.

3. Lateral pipe bending forces shall be isolated from all fittings.

4. PVC pipe deflections may be made either at joints or by pipe bending, as allowed by AWWA C605.

a. For jointed PVC pipes 12-inch diameter or smaller, pipe bending shall be allowed, provided that such bending complies with AWWA C605 and/or pipe manufacturer's minimum allowable bending radius, whichever is more stringent.

b. For jointed PVC pipes 14-inch diameter or larger, deflections shall be made at the pipe joints only.

c. For all pipe diameters, jointed PVC pipe joint deflection shall not exceed 1 degree per joint.

5. Steel and ductile iron pipe deflections shall be made at joints, provided pipe manufacturer's allowable deflection limits are not exceeded.

6. Mechanical Joints: contractor to abide by manufacturer's recommended maximum allowable deflection

7. Horizontal and vertical deflections in HDPE pipe shall be accomplished by pipe bending, provided that such bends meet the minimum bending radius recommended by the pipe manufacturer and AWWA (in case of discrepancy, the longer of the two radii shall be used).

J. Horizontal and vertical pipe line and grade

1. The horizontal and vertical lines and grades shown on the Drawings indicate the intent of the design. Actual horizontal and vertical lines and grades in the field may deviate from those shown on the Drawings, provided all of the following conditions are met:

a. Actual minimum slope of pipe shall not be less than 0.00100 ft/ft.

b. Actual maximum slope of pipe shall not be greater than 0.40000 ft/ft, except where otherwise noted on the Drawings.

c. Direction of pipe slope shall not differ from that shown on Drawings.

d. Minimum pipe cover of 4 feet shall be maintained throughout the project.

e. Additional minimum cover or specific minimum vertical clearances called out on the Drawings at specific locations, such as wash crossings, road crossings or pipeline crossings, shall be maintained.

f. In the case of horizontal bends, the outer wall of the pipe must remain at least 12 horizontal feet within the permanent right-of-way boundaries.

g. At bends near casings, pipe bending and/or off-set from centerline shall be done on the far side of the PI from the casing, to maximize the length of straight pipe in the sleeve on each side of the casing.

h. In certain locations, the pipe elevation and/or slope must remain as shown on drawings to facilitate pipe draining, maintain pressures, or other performance criteria. In such cases, deviation from the Drawings may not be allowed.

i. All deviations from the Drawings shall be documented by the Contractor and must be approved in advance by the Engineer.

j. All other specifications shall be met.

k. Any exceptions to the foregoing conditions must receive prior written approval by the Engineer.

2. No high points of any magnitude shall be allowed without an approved air valve. If the As-Built survey of the pipeline reveals high points not shown on the Drawings, Contractor shall correct the pipe grade or install additional air valves, as directed by Engineer.

   a. Additional air valves required due to unforeseen field conditions not the fault of the Contractor shall be paid for at the prices established in the Bid.

   b. Additional air valves or pipe re-installation required due to high points caused through fault of the Contractor shall be provided at no additional cost to the Owner. This includes failure of Contractor to meet lines and grades set forth in the Drawings or failure to meet minimum pipe slope.

      1) If the required air valve is located on restrained section of main line, a reducing tee is required in lieu of tapping sleeve. If a reducing tee is required within a corrosive soil zone, Contractor shall provide cathodic protection for the tee at no additional cost to the Owner.

K. Install pipe to bear on the trench bottom along entire length of pipe. For jointed pipe, excavate bell holes in the bottom of the trench to prevent the bell from coming into contact with the sub-grade.

L. Do not lay pipe in wet or frozen trench.

M. Direction of pipe bells may be reversed for ease of installation, provided that all pipe material and installation meets applicable AWWA, ASTM, NTUA and material manufacturer's standards. On grades greater than 10%, install jointed pipe uphill.

N. Pipe expansion and contraction

1. Install pipe to allow for expansion and contraction without stressing pipe or joints.

2. Allow all HDPE pipe to acclimate to sub-surface soil temperature by laying pipe in trench, embedding and backfilling, then waiting overnight prior to connecting pipe to any fitting or appurtenance (including butterfly valve and air valve assemblies).

O. Do not allow trench water, dirt, debris or other foreign material to enter the pipe during or after installation.

1. Keep pipe ends sealed after joining pipes, both while pipe string is laying on top of ground and after pipe is lowered into trench.

2. Close pipe openings with watertight plugs during work stoppages.

P. Clean inside of pipe by "pigging" immediately prior to connecting pipe ends to butterfly valves, elbows or other fittings that do not allow the pig to pass through. Seal all exposed pipe ends to prevent contamination after pigging.

1. Flanged ends shall be temporarily sealed using approved blind flanges. Straight pipe ends shall be temporarily sealed using approved pipe covers.

2. Pigging system shall be submitted to Engineer for approval prior to use.

Q. Install tracer wire continuous, taped to top of pipeline; coordinate with Sections 31 23 17 and 31 23 23.

R. Install metal-backed detectable water marker tape continuous over top of pipe, buried 18 inches above pipe; coordinate with Section 31 23 17 and 31 23 23.

S. Install thrust blocks at locations indicated on Drawings. Installation of thrust blocks shall not relieve the Contractor of responsibility to provide pipe restraints as indicated on Drawings and Specifications.

T. Flanged Joints: Not to be used in underground installations except within accessible structures or as shown on Drawings.

U. All pipes, fittings and appurtenances must remain within designated permanent rights-of-way. All construction activities must remain within the right-of-way or temporary construction easement. Do not encroach on adjacent properties or culturally sensitive areas.

V. Embed pipe within 100 feet behind pipe-laying operations, unless otherwise permitted by the Engineer.

W. Do not backfill pipe prior to as-built surveying; refer to Section 02 21 13 - Surveying.

3.6 JOINING POLYETHYLENE PIPE

A. HDPE pipes shall be butt-fused in the field in accordance with ASTM F2620.

B. Heat Fusion Joining: Joints between plain end pipes and fitting shall be made by butt fusion. Joints between the main and saddle branch fittings shall be made either using saddle fusion or with a factory-welded fitting. Either procedure used must be recommended by the pipe and fitting manufacturer.

C. Polyethylene pipe and fittings may be joined to other materials by means of:

1. Mechanical Joint (MJ) adapters with steel back-up rings and stainless steel stiffeners, where indicated on Drawings

2. Flange adapters with steel back-up rings, where indicated on Drawings.

D. ID Stiffener and Restraint: A stainless stiffener shall be installed in the bore of the polyethylene pipe when an OD compression mechanical coupling is used and when connecting plain end PE pipe to a mechanical joint pipe, fitting or appurtenance. External clamp and tie rod restraint shall be installed where PE pipe is connected to the socket of a mechanical joint pipe, fitting or appurtenance except where an MJ adapter is used. Stiffeners shall also be used in all HDPE MJ adaptors.

E. Mechanical Joint and Flange Installation: Mechanical joint and flange connections shall be installed in accordance with the manufacturer's recommended procedure. MJ adapter and flanges shall be centered and aligned to the mating component before assembling and tightening bolts. In no case shall MJ gland or flange bolts be used to draw the connection into alignment.

F. Mechanical couplings shall be fully pressure rated and fully thrust restrained such that when installed in accordance with manufacturer's recommendations, a longitudinal load applied to the mechanical coupling will cause the pipe to yield before the mechanical coupling disjoins. External joint restraints shall not be used in lieu of fully restrained mechanical couplings.

G. Do not perform fusions during adverse weather conditions, including high wind, any amount of blowing dust or precipitation events. Protect exposed pipe faces after facing and surface preparation from blowing dust. Engineer shall have the right to shut down fusing operations if weather conditions are not suitable or if weld quality is suspect. Contractor shall not be entitled to additional compensation for any such additional testing or shut-downs; however, shut-downs required by the Engineer through no fault of the Contractor (i.e. due to weather) shall be considered excused weather delays.

1. In the event of inclement weather, a tent, shelter, weld screen may be used to protect the fusion environment from dust, precipitation and heater plate variance. Any such enclosures must be approved by the Engineer. Engineer reserves the right to reject such enclosures and shut down operations if the enclosures do not adequately protect the pipe faces or fusion environment.

H. HDPE pipe may be welded into strings ("tie-in joining") and dragged into place, provided that pipe manufacturer's recommendations for maximum length, dragging velocity and other criteria are met.

I. All HDPE pipe butt fusions shall be performed in accordance with PPI Technical Report TR-33 and ASTM F2620 (latest edition). To the extent that these standards allow for accelerated cooling of HDPE butt fusion welds using chilled air, such methods may be used. However, all welds must be made in strict accordance with PPI and ASTM standards. Furthermore, all welds made using accelerated cooling methods must be warranted by the vendor of the cooling equipment for a period of not less than three (3) years after the date of the weld fusion.

J. Internal weld beads from all HDPE welds (on both pipe and fittings) shall be completely removed prior to installation, using Engineer-approved method for weld bead removal.

K. Protect HDPE at all times during handling, storage, transport, cutting and fusion from oil contamination.

1. Clean or wipe blades of facing equipment in accordance with equipment manufacturer's recommendations. Unless otherwise indicated by the manufacturer, do not use solvents for cleaning, as these can leave residues that can weaken the fusion joints and cause failures.

2. When cutting HDPE pipe with a chainsaw, do not add any liquid to the oil reservoir as this will contaminate the pipe. Direct exhaust from any gas-powered chain saw away from the pipe to ensure no oil residue forms on the outside of the pipe.

3.7 INSTALLATION - TAPPING SLEEVES AND SADDLES

A. Install tapping sleeves and valves in accordance with Drawings and in accordance with manufacturer's instructions.

B. For dry taps, after drilling into the pipeline, remove all pipe shavings and debris from inside the pipe using a vacuum or other method approved by the Engineer.

C. Do not install tapping sleeves or saddles on restrained PVC pipe. All taps on restrained PVC main lines must use MJ reducing tees.

D. Do not allow non-stainless components of tapping saddles or sleeves to come in contact with soil.

1. If any non-stainless part of a tapping saddle or sleeve is installed in contact with soil in a corrosive soil zone, as designated on the Drawings and/or this Section, cathodic protection shall be provided.

3.8 INSTALLATION – BOLTS

A. Apply heavy duty anti-seize to lubricate all stainless steel bolts.

B. Anti-seize compound shall be recommended by manufacturer for use with stainless steel.

3.9 INSTALLATION – STAINLESS STEEL THREADED PIPES AND APPURTENANCES

A. All threaded stainless steel pipes, valves, and fittings shall be wrapped with Teflon graphite tape and/or coated with anti-seize compound approved by manufacturer specifically for use with stainless steel threads.

3.10 THRUST RESTRAINT

A. All restrained PVC shall be accomplished with thrust blocking. Bell restraint harnesses are not allowed.

B. Install restrained fittings in accordance with Drawings and in accordance with manufacturer's instruction.

C. All thrust blocks shall bear against undisturbed earth.

3.11 HDPE WALL ANCHORS

A. Fuse HDPE wall-anchor ring to pipe at specified location. HDPE anchor ring shall be of the same material, inner diameter and pressure rating at the pipe to which it is fused.

B. Cast-in-place reinforced concrete wall anchor block per Drawings and in accordance with Section 30 10 00, Section 30 20 00 and Section 30 30 00, as applicable.

C. Concrete wall anchor block shall bear against undisturbed earth on the HDPE side of any transition between HDPE pipe and other pipe material, to prevent movement due to tensile ("pull-back") force exerted by the HDPE.

3.12 BACKFILLING

A. In accordance with Section 31 23 23.

3.13 INSTALLATION – CORROSION PROTECTION AND MONITORING SYSTEMS

A. Refer to Cathodic Protection Specification.

B. Design, install, energize, adjust and test sacrificial anode cathodic protection systems and corrosion monitoring stations for all buried ferrous pipe, valves and fittings within the following designated corrosive soil zones:

Station (ft)	Description	Apparent Resistivity (ohm-m)
0+00	Tank No. 2	27.01
46+37	Flush Valve	24.60
93+05	HDD Start	26.72
159+07	Casing	12.97
183+00	Tank Site No. 3	3.19 to 18.22

3.14

3.14 PIPELINE RIGHT-OF-WAY GRADING

A. Mound spoils over pipe as indicated on Drawings. Provide a level 5 ft break in earthen mound every 50 ft to prevent surface runoff from accumulating on the uphill side of the mound.

B. Establish finished grade to provide a minimum of four (4) foot of cover over the pipe. Measure depth of cover from final surface grade to top of pipe barrel.

1. At certain locations, such as wash crossings, road crossings, utility line crossings or to prevent high points, the Drawings indicate greater than 4 ft minimum cover. At such locations, Contractor shall maintain the site-specific minimum cover.

C. Do not place fill material or raise the finished grade above existing grade in the flow lines of washes or surface water drainages, regardless of size.

D. Finished grade along pipeline right-of-way and temporary construction easement shall have a maximum longitudinal slope of 4:1 and maximum side slope of 4:1, unless otherwise noted on Drawings.

E. The pipeline right-of-way shall be leveled from side-to-side to slow down surface run-off from causing erosion rills perpendicular to the pipeline, as well as to make the ROW accessible to the Owner for future maintenance.

1. The entire right-of-way shall be re-seeded and reclaimed after construction. Do not build any new roads. Refer to Section 32 92 19 – Seeding for re-seeding requirements.

2. The right-of-way shall not be open to the general public and shall have minimal impact on the environment. Upon completion of construction, the right-of-way shall be reclaimed to visually blend in with the surrounding environment and minimize its visual impact.

F. All construction activities, including clearing and grading, must remain within the designated right-of-way and temporary construction easement. Do not encroach on adjacent properties or culturally sensitive areas.

G. Final acceptance of ROW grading and restoration on Bureau of Land Management (BLM) lands shall be subject to approval by BLM.

3.15 TAPPING EXISTING WATER DISTRIBUTION FACILITIES

A. Obtain permission to tap from the Navajo Tribal Utility Authority (NTUA) for connecting to the ENWP Phase 3 waterline. A Permission to Tap application form is required to be provided to NTUA. Contractor shall not connect to existing system without written permission from NTUA and the Engineer to proceed with connection to the existing system.

B. Coordinate with NTUA's designated representative regarding schedule, means and methods, maximum allowable shut-off time, water usage rates (both gpm and gpd) and other parameters stipulated by NTUA.

C. Perform all work in conformance with the tapping permit and all written and verbal instructions from NTUA personnel, including notification and coordination with NTUA, maximum water usage rates, time and duration of shut-offs, and disinfection requirements.

D. Minimize shut-off time during connections to existing facilities. Contractor shall have all tools and materials for actual field conditions as well as foreseeable problems on hand in order to minimize shut-off time.

E. Taps on existing NTUA pipelines shall be by cut-in tees, with NTUA's approval. Wet taps shall not be permitted.

F. Prevent contamination of existing facilities with trench water, mud, debris, chemicals or other substances.

G. All new materials shall be thoroughly cleaned and disinfected with a strong (200 ppm) chlorine solution prior to connecting to existing NTUA facilities.

3.16 INITIAL FILLING OF PIPELINE

A. "Initial filling" refers to first introduction of water and evacuation of air in the pipeline.

B. Initial filling of pipeline shall not exceed maximum instantaneous flow rate (in gpm) or maximum daily fill rate (in gpd) set forth by NTUA and the Engineer in the field.

C. Unless otherwise directed by the Engineer, the maximum allowable instantaneous flow rate for the 24" Reach 21 raw waterline (upstream of the Water Treatment Plant) shall be 1360 gpm, and for the 20" Reach 21 finished waterline (downstream of the Water Treatment Plant) shall be 955 gpm.

3.17 DISINFECTION OF POTABLE WATER PIPING SYSTEM

A. Flush and disinfect system in accordance with Section 33 13 00.

3.18 FIELD QUALITY CONTROL

A. Section 01 00 00 - Execution Requirements: Field inspecting, testing, adjusting, and balancing.

B. The Contractor shall be required to hydrostatic pressure test all water mains, appurtenances and plumbing trains.

1. Perform testing in accordance with applicable standards:

a. Test pressure: In accordance with test pressure summary table.

b. PVC pipe: Simultaneous hydrostatic pressure and leakage test. The system shall be pressure tested in accordance with AWWA C605 and M23, with the exceptions noted below:

1) Test duration: 2 hours minimum.

a) Engineer may require longer duration test (up to 24 hours) if there is any doubt as to integrity of a particular section of pipe or appurtenances.

c. Ductile iron pipe: AWWA C600

d. Steel pipe: AWWA C200

e. HDPE pipe: ASTM F2164

1) HDPE pipe shall be hydrostatically tested above ground prior to installation.

2) Hydrostatic test shall be completed at an ambient temperature of 80° F or below. Contractor shall submit testing plan to engineer if planned hydrostatic test to be completed at an ambient temperature above 80° F.

3) Under no circumstances shall HDPE pipe be maintained at test pressure for more than 8 hours. If the test is not completed within this time, the system shall be depressurized and allowed to "relax" for a minimum of 8 hours before commencing the next test sequence.

2. In no case shall the test pressure exceed the manufacturers' recommended maximum safe test pressure for the pipe, fittings or appurtenances.

3. Hydrostatic pressure testing of main line shall be performed in sections between each pair of adjacent isolation valves. Do not skip any isolation valves in delineating test sections, without express written permission by Engineer.

4. No observable leakage is allowed. Measurable leakage must be within the maximum allowable limits set forth by applicable AWWA and ASTM standards.

5. Any leaks detected during testing shall be repaired. After repairs are completed, another full duration test shall be performed on the section of the pipeline to which the repairs were made.

6. All air must be vented from the pipeline prior to pressurization.

7. The pipeline must be fully restrained prior to pressurization, including permanently installed items and any temporary appurtenances used for testing.

8. All hydrostatic pressure tests must be witnessed by NTUA personnel. Contractor is responsible for coordination of testing schedule with NTUA to allow NTUA's representative to be present.

C. Qualifications of polyethylene fusion personnel:

1. Prior to production of heat fusion joints, the heat fusion joint machine operator shall be certified by the machine manufacturer or representative thereof who is approved by the Engineer.

2. Each fusion machine operator shall receive training on the use of the specific fusion machine and the bonding procedure and shall perform at least one pipe-to-pipe bond and one pipe-to-fitting bond (if used) on each machine they are required to use. All bonds made as part of operator certification shall be visually inspected and tested in accordance with the fusion quality testing specifications set forth in this section.

3. A fusion machine operator's qualification shall remain in effect for a period of six months from the date of qualification. The entity certifying an operator's qualifications shall retain the ability to revoke an operator's qualification if it is determined that there is a specific reason to question the operator's ability to make joints that meet project specifications.

D. Polyethylene pipe fusion machine data loggers:

1. All polyethylene pipe fusion machines shall be equipped with data loggers to record, at a minimum, joint temperature, pressure and time.

2. Data loggers shall be used during all joint fusions.

3. The Contractor shall provide data on any and all fusion joints upon request of the Owner or Engineer.

E. Fusion Quality Testing on Polyethylene pipe: The Contractor shall verify field fusion quality by making and testing a trial fusion as follows:

1. Frequency: Minimum of one trial fusion per crew per week or at any other time requested by the Owner or Engineer, up to a maximum of 10% of welds. Changes in weather during course of day, including increase in wind velocity or blowing dust, precipitation events or severe changes in temperature, may require additional tests at the discretion of the Engineer. Changes to fusion machine shall also require additional tests.

2. Procedure: The trial fusion shall be allowed to cool completely; then test coupons shall be cut out and tested in using Tensile Impact Method accordance with ASTM F2634.

a. For convenience, Contractor may use other, non-ASTM field tests to gather immediate general information regarding weld quality; however, such tests shall not replace the ASTM F2634 test. Only the ASTM F2634 test shall be used by the Engineer as a basis of whether to accept or reject any welds.

3. Rejection of fusion joints:

a. Any joint that exhibits a yield point lower than that of the unfused pipe or that fails in a brittle mode is considered unacceptable.

b. If the tensile impact test of the trial fusion fails, all field fusions represented by the trial fusion shall be rejected. The Contractor, at his expense, shall make all necessary corrections to equipment, set-up, operation, and fusion procedure, and shall re-make the rejected fusions. In the event that some or all of the rejected joints are already installed, the Contractor shall remove and re-install the pipe at no additional cost to the Owner.

F. Testing of field welds on steel pipe and fittings shall be by ultrasonic or radiographic method in accordance with AWS D1.1.

1. The Engineer reserves the right to demand evidence of welder's certification for all personnel performing field welding of steel pipe and fittings.

G. Thermal contraction and expansion of HDPE pipe:

1. Engineer reserves the right to unbolt any flange or mechanical joint attached to HDPE pipe (including all butterfly valve assemblies) to check for tensile or compressive loading due to thermal contraction or expansion of the HDPE pipe. Excessive tension, indicated by pull-back of the HDPE end, or excessive compression of the flange shall be cause for the Contractor to excavate the HDPE pipe, lengthen or shorten the pipe as necessary, and re-bury. Contractor shall not grout the pipe penetrations of valve vaults until authorized by the Engineer, to allow for proper testing. Refer to Section 33 12 16 – Water Utility Valves.

H. Compaction Testing: Refer to Section 31 23 23 – Backfill.

I. Testing of cathodic protection systems: Refer to Cathodic Protection Specification.

J. Test electrical isolation kits for cathodic protection isolation using radio frequency isolation test device both prior to burial and after burial. Test in the presence of the Engineer.

K. All tracer wire must be field checked for continuity after all excavation is completed, but prior to Final Completion of the project. All breaks in continuity shall be corrected.

L. When tests indicate Work does not meet specified requirements, remove Work, replace and retest at no additional cost to the Owner.

3.19 TOLERANCES

A. Line and grade surveying tolerances:

1. See Section 02 21 13 – Surveying.

B. Flange alignment tolerances as specified in AWWA C207 and AWWA M11.

END OF SECTION

SECTION 33 12 16

WATER UTILITY VALVES

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:

1. Gate Valves.
2. Butterfly Valves.
3. Ball Valves.
4. Orifice Plates.
5. Air Valves.
6. Dismantling Joints.
7. Flush Valve Assemblies.
8. Valve boxes.
9. Meter cans.
10. Pipe Supports
11. Valve vaults.
12. Accessories.
13. Corrosion Protection.

B. Related Sections:

1. Section 03 30 00 - Cast-in-Place Concrete.
2. Section 31 22 13 - Rough Grading.
3. Section 31 23 23 - Backfill.
4. Section 33 11 13 - Public Water Transmission Systems.
5. Section 33 13 00 - Disinfection of Water Utility Transmission Systems.

1.2 UNIT PRICE - MEASUREMENT AND PAYMENT

A. Vacuum Breaker and Air Valve Assemblies:

1. Basis of Measurement: Each.
2. Basis of Payment: Includes excavation, vacuum breaker / air valve assembly, concrete vault with ladder, cover and hatch, fittings, accessories and backfill.

B. Site Butterfly Valve Assemblies:

1. Basis of Measurement: Each.

2. Basis of Payment: Includes excavation, butterfly valves, adaptors, fittings, valve boxes, lids, meter cans, collars, identification placards, warning placards, collars, accessories, and backfill.

C. Site Gate Valve Assemblies:

1. Basis of Measurement: Each.
2. Basis of Payment: Includes excavation, gate valves, adaptors, fittings, valve boxes, lids, meter cans, collars, identification placards, warning placards, collars, accessories, and backfill.

D. Main Line Butterfly Valve Assemblies:

1. Basis of Measurement: Each.
2. Basis of Payment: Includes excavation, main line butterfly valves, by-pass valves, by-pass piping, orifice plates, adaptors, fittings, valve boxes, lids, meter cans, collars, warning placards, accessories, and backfill.

E. Flush Valve Assemblies:

1. Basis of Measurement: Each.
2. Basis of Payment:
   a. 4-inch Flush valve with wash outfall: Includes excavation, 4-inch piping, 4-inch gate valve assembly as shown on plans, drain line, orifice plate, rubber check valve, outfall structure, fittings, meter can and riser (where applicable), accessories and backfill.

F. Cathodic Protection:

1. Refer to Section 33 11 13.

1.3 REFERENCES

A. American Association of State Highway and Transportation Officials (AASHTO)

1. AASHTO M 306-10 - Standard Specification for Drainage, Sewer, Utility and Related Castings

B. ASTM International (ASTM)

1. ASTM A48 – Standard Specification for Gray Iron Castings
2. ASTM A126 – Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings
3. ASTM A536 – Standard Specification for Ductile Iron Castings
4. ASTM A564 – Standard Specification for Hot Rolled and Cold Finished Age Hardening Stainless Steel Bars and Shapes
5. ASTM B62 – Standard Specification for Composition Bronze or Ounce Metal Castings
6. ASTM B148 – Standard Specification for Aluminum Bronze Sand Castings
7. ASTM C478 – Precast Reinforced Concrete Manhole Sections

8. ASTM F593 – Standard Specification for Stainless Steel Bolts, Hex Cap Screws, and Studs

9. ASTM F594 – Standard Specification for Stainless Steel Nuts.

10. ASTM A312 – Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipe

11. ASTM D3363 – Standard Test Method for Film Hardness by Pencil Test

12. ASTM D4752 – Standard Practice for Measuring MEK Resistance of Ethyl Silicate Zinc Rich Primers by Solvent Rub

13. ASTM D638 – Standard Test Method for Tensile Properties of Plastics

C. American Water Works Association (AWWA):

1. AWWA C207 – Standard for Steel Pipe Flanges for Waterworks Service

2. AWWA C507 - Ball Valves 6 inch through 48 inch

3. AWWA C515 – Reduced-Wall, Resilient-Seated Gate Valves for Water Supply Service.

4. AWWA C550 - Protecting Epoxy Interior Coating for Valves and Hydrants.

5. AWWA C605 - Underground Installation of Polyvinyl Chloride PVC Pressure Pipe and Fittings for Water.

6. AWWA M11 – Steel Pipe: A Guide for Design and Installation

7. AWWA M23 – PVC Pipe – Design and Installation

D. American National Standards Institute

1. ANSI B16.1 Gray Iron Pipe Flanges and Flanged Fittings

E. NACE International (NACE)

1. SP0274 – High-Voltage Electrical Inspection of Pipeline Coatings Prior to Installation.

F. NSF International/ American National Standard (ANSI):

1. NSF/ANSI Standard 61 - Drinking Water Components - Health Effects.

G. Society for Protective Coatings:

1. SSPC-SP1 – Solvent Cleaning

2. SSPC-SP2 – Hand Tool Cleaning

1.4 SUBMITTALS

A. Design Data: Submit manufacturer's latest published literature. Include illustrations, installation instructions, maintenance instructions and parts lists.

B. Manufacturer’s Certificates: Submit Statement of Compliance, supporting data from material suppliers attesting that valves and accessories provided meet or exceed AWWA Standards and specification requirements.

C. Submit proofs on all signs, placards, and tags prior to fabrication.

1.5 CLOSEOUT SUBMITTALS

A. Project Record Documents: Record actual locations of valves.

B. Provide Operation and Maintenance Data for each type of valve installed.

1.6 QUALITY ASSURANCE

A. Perform work in accordance with applicable New Mexico Standards and the National Fire Protection Act (NFPA).

B. Valves: Mark valve body with manufacturer's name and pressure rating.

1.7 DELIVERY, STORAGE AND HANDLING

A. Prepare valves and accessories for shipment according to AWWA Standards and seal valve ends to prevent entry of foreign matter into product body.

B. Deliver and store valves in shipping containers with labeling in place.

C. Store products in areas protected from weather, moisture, or possible damage; do not store products directly on ground; handle products to prevent damage to interior and exterior surfaces.

D. Coated valves and appurtenances shall be shipped on bunks and secured with nylon belt tie down straps or padded banding over braces, and shall be stored on padded skids or other suitable means to prevent damage to coatings.

E. Coated valves shall be handled with wide belt slings, padded forks or other means to prevent damage to coatings. Chains, cables or other equipment likely to damage coatings or valves shall not be used.

1.8 ENVIRONMENTAL REQUIREMENTS

A. Conduct operations not to interfere with, interrupt, damage, destroy, or endanger integrity of surface or subsurface structures or utilities, and landscape in immediate or adjacent areas.

1.9 MAINTENANCE MATERIALS

A. Furnish two (2) tee wrenches to Owner for each valve type.

PART 2 PRODUCTS

2.1 GENERAL

A. All valves shall be American made, unless otherwise specified.

B. All non-stainless steel and iron valves and appurtenances shall be fusion bonded epoxy coated, interior and exterior, conforming to AWWA C550 and NSF 61.

C. All valves and coatings shall be NSF 61-certified.

D. All bolts, nuts, and washers (where required) shall be stainless steel 304, unless otherwise specified, and shall be provided by the valve or fitting manufacturer especially for use with their respective valves or fittings. If manufacturer cannot supply stainless steel bolts for the MJ or flange connection, Contractor may provide bolts from another source; however, Contractor is solely responsible to ensure fit and compatibility of said bolts.

2.2 RESILIENT WEDGE GATE VALVES

A. Manufacturers:

1. Mueller Company

a. A-2361

2. Substitutions: Approved Equal

B. Resilient Wedge Gate Valves: AWWA C515, NSF 61, American-made; ductile iron.

1. Resilient seats.

2. Stem: Non-rising bronze stem.

3. Operating Nut: Square; open counterclockwise unless otherwise indicated.

4. Valve Ends:

a. Mechanical joint or flanged, as indicated on Drawings.

b. Flanged ends shall be drilled in accordance with ANSI Class 125/150 bolt pattern, unless otherwise noted on Drawings.

c. Pressure rating not less than that of valve body.

5. Working pressure rating: 350 psi.

6. Pressure testing: Seat test – 525 psi for 15 seconds, test seat from each side of valve separately per UL262. Shell test pressure: 700 psi.

7. Inside and outside of valve fully coated with Fusion Bonded Epoxy, 10 mils nominal, conforming to AWWA C550 and NSF 61 requirements.

C. Where waterline is buried at a depth greater than 4 feet, provide valve stem extensions, complete with extension stem stabilizers, until depth of extension nut matches depth of operating nuts on valves installed at four-foot depth.

2.3 BUTTERFLY VALVES

A. Manufacturers:

1. Henry Pratt Co.

a. Groundhog

2. Val-Matic Valve and Manufacturing Corporation

a. Series 2000

3. Substitutions: Not permitted.

B. 150 psi Butterfly Valves:

1. Conforming to AWWA C504, Pressure class AWWA 150B, MSS SP 67 and NSF 61.

2. Rated to 150 psi full differential working pressure.

3. Shell test pressure 300 psi.

4. Leak test at 150 psi.

5. Body: Ductile iron, drilled in accordance with ANSI B16.1 Class 125, stainless steel shaft. Body wall thickness shall be in accordance with AWWA C504.

C. Valve Ends:

1. Mechanical joint or flanged, as indicated on Drawings.

2. Flanged ends shall be drilled in accordance with ANSI Class 125/150 bolt pattern.

3. Pressure rating not less than that of valve body.

D. Disc: Epoxy-coated cast iron, with stainless steel 316 edge.

E. Seat: Resilient Buna N.

F. Shafts: Shall be sized, designed and constructed in conformance with AWWA C504 for pressure class AWWA 150B. Shafts shall be SS ASTM A-276 Type 304.

G. Handle and Operator:

1. Direct buried service.

2. Manual actuators shall conform to AWWA C504 for pressure class AWWA 150B.

3. Actuators shall be buried service type with square operating nut, shall be of traveling nut, self-locking type able to hold valve in any intermediate position without fluttering or creeping. Actuators shall have external travel stops for open and closed position adjustment. Internal stops which require actuator cover and grease removal shall not be used.

4. Actuator shall have mechanical stops able withstand input torque of 450 ft-lb against each stop.

5. Open left, close right.

6. Buried service actuators shall be grease packed.

H. Where valve is direct buried at a depth greater than 4 feet, provide valve stem extensions, complete with extension stem stabilizers, until depth of extension nut at least matches depth of operating nuts on valves installed at four-foot depth.

2.4 BALL VALVES

A. Stainless steel ball valves for air and vacuum breaker valve assemblies

1. Size: ¼-inch, ½-inch, 1-inch, 2-inch, or 3-inch, as shown on Drawings

2. May be imported or domestic

3. Manufacturers:

a. Milwaukee Valve

b. Apollo

c. Approved equal

4. Working Pressure: Not less than 250 psi

5. Inlet/Outlet: FNPT, or as shown on Drawings

6. All stainless steel construction, including body, tailpiece, ball, ball retainer, stem, handle, handle nut, packing nut, and lock washer

7. Valve shall be actuated manually using lever-type handle, one-quarter turn to open and close. Handle length and range of motion shall allow handle to be located in the most accessible location without interference with any other object.

2.5 ORIFICE PLATES

A. Stainless steel 304

B. Thickness 3/8” or as shown on plans

C. Orifice shall be beveled at 45° angle, 3/16” deep on downstream side.

D. Fabrication:

1. Orifice plates shall be fabricated and drilled with a single concentric hole of the proper diameter for each installation as indicated on the Drawings. Both faces of the plate shall be machined smooth to remove all burrs, ridges and other imperfection in the flow area. Mating edges shall be machined to the same tolerances as flange mating faces (see Section 33 11 13). The orifice holes shall be machined to a tolerance of +/- 15 mils.

2.6 AIR VALVES

3-inch vacuum breaker valve with 7/32-inch air release valve:

1. Manufacturer:
 a. Val-Matic Valve and Manufacturing Corporation. Dual-body Type.
 b. Vacuum breaker model 1803AVB; Air release valve model 45.5.
 c. Substitutions: Not permitted

2. Working pressure: 200 psi

3. Outlet: 3”, flanged, ANSI Class 125

4. Cast iron or ductile iron body, cover and baffle; stainless steel trim, float, and fasteners.

5. Seat: Resilient Buna N.

6. Valve to perform functions of both air release and vacuum relief.
 a. Vacuum breaker orifice: 3”
 b. Air release orifice: 7/32”
  1) Air release valve to be mounted adjacent to vacuum breaker valve.

7. Stainless steel 304 piping, valve, and fittings between vacuum relief valve and air valve bodies.

8. Internal and external coatings shall be fusion bonded epoxy conforming to NSF-61 requirements.
9. Hood: Valve assembly shall include hood mounted permanently to the valve outlet opening.

2.7 DISMANTLING JOINTS

1. Manufacturer:
   a. ROMAC, Model DJ400
   b. Substitutions: Approved Equal
2. Flanges: ANSI Class 250
3. NSF 61 Certified fusion bonded epoxy coating
4. Color: Blue
5. NBR gasket
6. Integral Tie Rods
7. 316 stainless steel fasteners
8. Working pressure: 300 psi

2.8 FLUSH VALVE ASSEMBLIES

A. Components of flush valve assembly shall be as provided elsewhere in project specifications.
B. Rubber check valves:
   1. Manufacturers:
      a. Tideflex Series 35
      b. Proco Series 710
      c. Approved Equal
   2. End: Flanged
C. Ductile iron drain pipe sections shall be polyethylene-wrapped in accordance with AWWA C105, Installation Method “A”.

2.9 VALVE BOXES

A. 12-inch diameter valves and smaller: Domestic cast iron, two-piece, slip type.
B. Valves larger than 12-inch diameter: Domestic cast iron, three-piece, slip type; round base.
C. Where waterline is buried at a depth greater than 4 feet, provide valve box extensions as required.
D. Cast iron lid marked “Water”.
E. Heavy duty, traffic rated.

F. Valve boxes with warning placards shall have locking lids with standard pentagon nut, which shall be installed below grade in heavy-duty traffic-rated meter cans.

G. Valve boxes without warning placards shall have non-locking lids.

H. Wrap bottom in plastic to prevent soil from entering.

2.10 METER CANS

A. Frame and cover:

1. Traffic-rated to H20 proof load of 20,000 lbs applied on a 9” x 9” steel plate in center of cover for one minute.
2. Reversible ring, ASTM A48 CL35B gray iron, undipped
   a. Shall fit the 18-inch CMP meter can specified below.
   b. 15-inch minimum opening size.
3. Cast iron lid shall have non-skid machined surface with "WATER" inscribed on the top
4. Type 2 Non-penetrating pick hole
5. Lockable lid
6. Frost proof design

B. Meter Can:

1. 18” inner diameter, 20 gauge corrugated metal pipe, length per detail drawing.
2. Maximum wall deflection shall not exceed $^{1}/_{8}$” at any one point when subtracted from earth pressures or forces created during backfilling.

C. Contractor responsible to ensure compatibility between corrugated metal pipe, flange, ring, and cover.

2.11 PIPE SUPPORTS

A. Manufacturer:

1. Standon, S8900 Series
2. Substitutions: Approved Equal

B. 304 stainless steel

C. Size per drawings

D. 8”x8”x3/8” thick base plate bolted to chamber floor

2.12 VALVE VAULTS

A. Concrete manhole sections conforming to ASTM C478.

1. Bell and spigot joints.
2. Symmetrical reinforcement only.
3. Soil-tight gasket conforming to ASTM C-990.

4. Embedded ladder rungs.

B. Concrete shall conform to Section 03 30 00 – Cast-in-Place Concrete.

C. Manufactured or cut to lengths shown on Drawings.

D. "Mouse hole" or circular cut-outs to accommodate main line pipe inside vaults, if needed, shall be pre-cast.

E. Pre-fabricated reinforced flat, slab-type lids with hinged, lockable hatches as shown on Drawings.

1. Shallow well manhole covers, where indicated on Drawings, shall be 24" diameter, as provided by Four Corners Precast, OAE. Steel pipe used for shallow well covers may be domestic or import.

F. Foam insulation.

1. 2" minimum thickness

2. Spray Foam Insulation.

a. 2-lb closed cell, two-component, rigid polyurethane.

b. R Value per inch of 6.6 or greater (K factor 0.15 or less).

c. Suitable for application to low temperature substrates (15°F).

d. Waterproof mixture in sealant

3. Sheet insulation may be considered by the Engineer as a substitute if demonstrated to meet or exceed the properties of spray foam insulation, including resistance to moisture build up or condensation behind the insulation. The burden to demonstrate the properties of any substitute shall be borne by the Contractor.

G. Two-way draft damper

1. Manufacturers:

a. Val-Matic, Frost Safe, VM-1504

b. Substitutions: Approved Equal

2. Field replaceable disc that opens fully to provide full flow area in both directions without requiring annular clearance with the body.

3. Contains no hinges or seats subject to freezing

2.13 VALVE IDENTIFICATION PLACARDS (FOR SITE VALVES ONLY)

A. Rectangular stainless steel 430 plate with 4 x ¼" pre-drilled holes

B. Dimensions: 8"w x 6"h x 0.029"t

C. Laser-etched lettering using Cermak LMM6000 laser marking promoter with 150 watt CO2 laser.

D. Arial font with 3/8" letter height, or as permitted by placard dimensions and pre-drilled holes, centered horizontally and vertically on placard.

E. Valve identification placards shall be affixed to concrete with four aluminum 3/16" dia. x 7/8" length hammer drive/metal-hit concrete anchors.

F. Submit a proof to Engineer for approval before producing placards.

2.14 WARNING PLACARDS FOR BUTTERFLY VALVE BOX LIDS

A. Rectangular aluminum plate with four (4) #30 (0.1285") pre-drilled holes to accommodate 1/8" dia. rivets, and 1 7/8" pre-drilled center hole.

1. Contractor responsible to verify diameter of center hole to correspond to outer diameter of key to locking nut of lockable valve box lid.

B. Dimensions: 4½"w x 4½"h x 0.04"t

C. White enamel-coated aluminum placard

D. Printed on 3.75 mil, 5 yr outdoor-rated calendared gloss vinyl with permanent solvent adhesive, printed with ECO-Solvent permanent ink.

E. Laminated with 2.5 mil calendared gloss over-laminate rated for 4 yr outdoor use.

F. White background with red and black lettering as shown on Drawings.

G. Arial font with 0.25" minimum height lettering, or as permitted by placard dimensions and pre-drilled holes.

H. Warning placards shall be affixed to lockable valve box lids with four 1/8" dia. x ¼" grip aluminum pop rivets.

I. Submit a proof to Engineer for approval before producing placards. Proof shall include placement of placard on the valve box cover to ensure proper fit and clearances.

2.15 VALVE IDENTIFICATION TAGS (FOR 3-INCH VACUUM BREAKER VALVES)

A. Identification tag:

1. Stainless steel 304 or 316
2. Natural metal color background with black lettering
3. Dimensions: 2" x 2" x 0.024" thick
4. Includes pre-cut hole for fastener. Contractor responsible for assuring pre-cut hole is properly sized for fastener.
5. Laser-etched lettering using Cermak LMM6000 laser marking promoter with 150 watt CO2 laser
6. Minimum letter/font height: 0.1", or larger depending on available printing space for each tag
7. Wording as indicated on drawings.

B. Fastener:

1. Stainless Steel #6 Beaded Chain

C. Submit a proof to Engineer for approval before producing tags.

2.16 ACCESSORIES

A. Concrete for thrust restraints, blocks and collars: Concrete type specified in Section 03 30 00.

2.17 STEEL PIPES AND FITTINGS

A. All steel pipes and fittings shall be Stainless Steel 304, unless otherwise noted.

B. Pressure rating: At least 350 psi Cold Working Pressure, unless otherwise noted.

2.18 STAINLESS STEEL THREAD PROTECTION

A. All stainless steel threads shall be protected with Teflon graphite tape and/or anti-seize compound approved by manufacturer specifically for use with stainless steel threads.

2.19 CORROSION PROTECTION

A. Refer to Section 33 11 13.

2.20 SOURCE QUALITY CONTROL

A. Coatings:

1. Cure testing for fusion bonded or liquid epoxy coatings: ASTM D4752 and ASTM D3363, Every 1000 sq. ft. of epoxy coating.

2. Holiday testing for epoxy coatings:

a. All fusion-bonded epoxy coatings on all valves shall be holiday tested prior to installation, at Contractor's expense.

b. Perform testing in accordance with NACE Standard SP0274, using electrical holiday tester. Use test voltage below:

Total Coating Thickness (Mils)	Test Voltage (Volts)
20 or less	6000
30	7500
50	9000
70	11500
80 or more	12000

c. All holidays shall be repaired and re-tested, at no additional cost to the Owner.

3. Touch up and repair of Fusion Bonded Epoxy Coatings

a. Applies to all FBE coated valves for field repair of minor holidays, scratches, breaks or other damage to FBE coating.

b. Does not include repair or touch up of systemic or large area holidays in FBE coating. Repair of systematic holidays or damaged areas larger than three (3) sq. in. will require the damaged coating be ground off and the valve be newly shop-coated.

c. Materials and application:

1) NSF/ ANSI 61 certified, two-part, 100% solids, liquid epoxy coating meeting the requirements of AWWA C210.

a) Manufacturer: 3M Scotchkote Epoxy Coating 323, OAE.

b) If temperature is below 55 degrees Fahrenheit, the metal substrate shall be pre-heated in accordance with coating manufacturer's recommendations prior to applying the coating.

d. Prepare surface and apply per coating manufacturer's instructions for use as a field repair material.

PART 3 EXECUTION

3.1 EXAMINATION

A. Determine exact location and size of valves from Drawings; obtain clarification and directions from Engineer prior to execution of work.

B. Verify invert elevations prior to excavation and installation of valves.

3.2 PREPARATION

A. Identify required lines, levels, contours and datum locations.

B. Locate, identify, and protect utilities to remain from damage.

C. Do not interrupt existing utilities without permission or without making arrangements to provide temporary utility services.

1. Notify Engineer not less than 48 hours in advance of proposed utility interruption.

2. Do not proceed without written permission from the Engineer.

D. Perform trench excavation, backfilling and compaction in accordance with Sections 31 23 17 and 31 23 23.

3.3 INSTALLATION

A. Valve scribing: All valve collars and vaults shall be scribed with the valve data.

1. Gate valve and butterfly valve collars shall be scribed neatly before the concrete has cured. If scribing of wet concrete is not possible, valve collars may be etched using a 4-inch grinder, with Engineer's approval in field.

2. Air valve vault lids shall be etched using a 4-inch grinder.

3. All valve collars and vault lids outside fenced sites ("main line valves") shall be etched with the following valve data:

a. Flow directional arrows

b. Station number in standard "STA XXX+XX" format, including the abbreviation "STA" in front of the number

c. Pipe size (if different from valve size) and material

d. Valve size and type (i.e. ARV, VB, GV, BFV)

e. Valve description for non-air valves (i.e. Transmission, By-pass, Flush)

f. Pipe material.

4. All valve collars and vault lids inside fenced areas ("site valves") shall be etched with:

a. Flow direction arrows

b. Valve type

c. Valve size

d. Pipe material

5. All valve collars and vault lids inside fenced areas ("site valves") shall be further labeled with a stamped 8" x 6" stainless steel placard, as specified above.

a. Follow anchor manufacturer guidelines for proper installation.

b. Contractor responsible for verifying anchor and anchor head diameters are compatible with holes in aluminum plate.

c. Valve identification placards shall contain the following valve data:

1) Valve number, as provided on site valve numbering plans

2) Valve size

3) Valve type (i.e. BFV, GV, etc.)

4) Description of valve function, as provided on site valve numbering plans

6. Contractor shall verify all data on the site valve numbering plans with Engineer prior to scribing of valve collars or fabrication of placards. Contractor shall be responsible for replacement of any incorrect placards or valve collars if this data is not verified by Engineer.

B. Valve box security and warning placards:

1. Affix warning placard, as specified above, to the top of valve box lid at locations indicated on Drawings.

a. Ensure placards centered within valve box lids and center hole aligned with locking nut. Do not allow corners of placard to overhang the lid.

b. Pre-drill holes in valve box lids and install rivets, per manufacturer's instructions. Ensure rivets grip properly into the lid.

2. All valves indicated as requiring warning placards shall be installed below grade inside meter cans, as shown on Drawings.

C. Valve Vaults

1. Thoroughly clean vault section ends with wire brush prior to joining sections.

2. Place vault sections with bell down.

3. Seal all vault sections with sealant approved by Engineer.

4. Grout lids as directed by Engineer.

5. Field apply foam insulation in accordance with manufacturer's instructions and recommendations. Personnel applying spray foam insulation shall be sufficiently trained by the manufacturer, the Center for the Polyurethane Industry, the Spray Polyurethane Foam Alliance, or similarly competent certifying body.

D. Apply heavy duty anti-seize to lubricate all stainless steel bolts. Anti-seize compound shall be recommended by manufacturer for use with stainless steel bolts.

E. Vacuum and Air Valve Assemblies

1. Install in accordance with AWWA standards and manufacturer's recommendations

2. After drilling into the main line, remove all pipe cuttings and other debris with a vacuum or other method approved by the engineer prior to installing the valve assembly.

3. Install vacuum and air valve assemblies in vertical position.

4. Where indicated at high points in pipe on Drawings, install at actual high points, as determined by as-built pipeline survey data.

5. Secure assemblies to Unistruts as shown on Drawings to prevent lateral movement or stresses.

6. Vacuum breaker air valve assemblies installed on restrained or fusible PVC main line shall have FBE-coated DI reducing tees in lieu of tapping sleeves. Reducing tees located in corrosive soil zones shall be cathodically protected.

7. Galvanized steel air vents shall be painted blue as follows:

a. Minimum surface preparation: SSPC-SP1

b. Primer: 1 coat Sherwin Williams Galvite HS, OAE

1) 3.0-4.5 mils dry film thickness

c. Finish: Two coats Sherwin Williams Industrial Enamel (B54 Series), OAE

1) 2.0-4.0 mils dry film thickness

d. Follow all other paint manufacturer recommendations for preparation and application.

F. Gate Valves and Butterfly Valves:

1. Install in accordance with AWWA standards and manufacturer's recommendations

2. Install valves in conjunction with pipe laying; set valves plumb.

3. Assemble complete valve assembly and place in open excavation at proper line and grade.

4. Provide buried valves with valve boxes or meter boxes installed flush with finished grade.

   a. Any valve box lids, meter can lids, or collars that do not meet grade requirements shown on Drawings shall be removed and replaced.

5. Install valve stem risers, collars and valve box extensions as required to match finished grade.

6. Gate valves and butterfly valves shall require the same thrust blocking as dead-ends of similar size and pipe material.

G. Flush Valves

1. Wash outfalls:

   a. Install drain lines at constant slope to daylight at banks of adjacent washes, as shown on Drawings. Orient outlets of drain lines pointing downstream in the wash from the pipeline. Angle outlet to minimize scour and erosion of wash from water discharged from blow-off, as directed in field by Engineer.

   b. Length of 4-inch, 45-degree riser pipe shall be determined in the field by Engineer, in order to allow end of drain pipe to outfall at the wash at correct elevation while maintaining required slope on the drain pipe.

   c. Length of 6-inch clean-out pipe shall be determined in the field by Engineer, in order to bring blind flange into meter can with meter can lid flush with surrounding finished grade.

   d. Install splash pad/outfall structures as directed in field by Engineer. Adjust flush pipe outlet to direct water flow into the riprap. Do not allow water stream to hit unarmored soil.

   e. Stations of tees to connect flush valves to main line are approximate. Adjust tee location as needed to provide adequate outfall height, drain pipe slope and cover.

H. Assemble steel flanged joints in accordance with AWWA M11 and AWWA C207.

I. No high points in the pipe of any magnitude shall be allowed without an appropriate vacuum/ air valve. If the As-Built survey of the pipeline reveals high points not shown on the Drawings, Contractor shall correct the pipe grade or install additional air valves, as directed by Engineer.

1. Additional air valves required due to unforeseen field conditions not the fault of the Contractor shall be paid for at the prices established in the Bid. Contractor shall promptly report such conditions to the Engineer.

2. Additional air valves required due to high points caused through fault of the Contractor shall be provided at no additional cost to the Owner. This includes failure of Contractor to meet lines and grades set forth in the Drawings or failure to meet minimum pipe slope.

   a. If the required air valve is located on a fusible or restrained section of main line, a reducing tee is required in lieu of tapping sleeve.

b. If a reducing tee is required within a corrosive soil zone, Contractor shall provide cathodic protection for the tee at no additional cost to the Owner.

J. Tracer wire:

1. For direct buried valves with surface valve box lids, tape tracer wire to outside of valve box up to last section of box. Bring tracer wire into the valve box above the operating nut. Coil 18” tracer wire inside valve box under the lid.

2. For direct buried valves with valve box lids inside meter cans, bring tracer wire into the meter can outside of the valve box. Coil 18” tracer wire inside meter can.

3. For all valve vaults, coil min. 24” tracer wire against wall on each side of vault.

K. All shallow well manhole covers, valve box lids, meter can lids, and other cast iron appurtenances visible from surface shall be painted blue as follows.

1. Minimum surface preparation: SSPC-SP2

2. Primer: Sherwin Williams Kem Kromik Universal Metal Primer, OAE

a. One coat, 3.0-4.0 mils dry film thickness

3. Finish: Sherwin Williams Industrial Enamel (B54 Series), OAE

a. Two coats, 2.0-4.0 mils dry film thickness

4. Follow all other paint manufacturer recommendations for preparation and application.

3.4 CORROSION PROTECTION

A. Refer to Section 33 11 13 and Drawings for designation of corrosive soil zones in which buried valve assemblies require cathodic protection and/or corrosion monitoring and for specifications for design, materials, installation, energizing and testing of cathodic protection systems.

B. Ferrous components not in contact with soil do not require cathodic protection.

C. Stainless steel components do not require cathodic protection.

D. Do not use polyethylene encasement for valves or fittings that have cathodic protection.

3.5 DISINFECTION OF DOMESTIC WATER PIPING SYSTEM

A. Flush and disinfect system in accordance with Section 33 13 00.

3.6 FIELD QUALITY CONTROL

A. Section 01 00 00 - Execution Requirements: Field inspecting, testing, adjusting, and balancing.

B. Perform pressure test on domestic site water transmission system in accordance with AWWA C605.

C. All valves, including butterfly valves, gate valves, and air valves shall be manually actuated through their full cycle to ensure proper operation prior to installation.

1. The Contractor shall provide the Engineer the opportunity to witness all valve actuations prior to valve installation.

D. Inspect coatings of all valves immediately prior to installation and repair all damaged coatings.

E. Properly align all pipes, valves and fittings prior to making connections. Do not install any pipes or fittings with internal longitudinal or shear stresses. Engineer reserves the right to disassemble any flange, joint, or union to check for internal stresses. Contractor shall correct any connection with internal stress at no additional cost to the Owner.

F. All tracer wire must be field checked for continuity after all excavation is completed, but prior to Final Completion of the project.

END OF SECTION

SECTION 33 13 00

DISINFECTION OF WATER UTILITY TRANSMISSION SYSTEMS

PART 1 GENERAL

1.1 SUMMARY

A. Section includes disinfection of potable water transmission system; and testing and reporting results.

B. Related Sections:

1. Section 33 11 13 - Public Water Transmission Systems: Product and Execution requirements for installation, testing, of site domestic water transmission system piping.
2. Section 33 12 16 - Water Utility Valves.

1.2 MEASUREMENT AND BASIS OF PAYMENT

A. Basis of Measurement: By the linear foot for pipeline and wash crossings. Incidental to work for all other facilities (incl. site piping and other facilities).

B. Basis of Payment: Payment for pipeline disinfection will be made based on linear footage, upon successfully passing bacteriological testing. Disinfection of other facilities (including tank, and site piping) shall be incidental to their respective bid items.

1. This includes all costs incidental to disinfection and testing, including chlorination, flushing, water for flushing, de-chlorination, sampling, sample transport, laboratory testing fees, and any other costs incidental to flushing, disinfection, and bacteriological testing activities.
2. Bacteriological testing costs shall not be allowed under the Testing Allowance.

1.3 REFERENCES

A. American Water Works Association (AWWA):

1. AWWA B300 - Hypochlorites.
2. AWWA B301 - Liquid Chlorine.
3. AWWA B302 - Ammonium Sulfate.
4. AWWA B303 - Sodium Chlorite.
5. AWWA C600 - Installation of Ductile-Iron Water Mains and Their Appurtenances.
6. AWWA C651 - Disinfecting Water Mains.

B. New Mexico Administrative Code (NMAC) - Title 20, Chapter 7, Part 10:

1. Section 201: Application for Public Water System Project Approval.
2. Section 400: General Operating Requirements.

1.4 SUBMITTALS

A. Section 01 00 00 - Submittal Procedures: Requirements for submittals.

B. Product Data: Submit procedures, proposed chemicals, and treatment levels for review.

C. Test Reports: Indicate results comparative to specified requirements.

D. Certificate: Certify cleanliness of water transmission system meets or exceeds specified requirements.

1.5 CLOSEOUT SUBMITTALS

A. Section 01 00 00 - Execution Requirements: Requirements for submittals.

B. Disinfection Report:

1. Type and form of disinfectant used.
2. Date and time of disinfectant injection start and time of completion.
3. Test locations.
4. Name of person collecting samples.
5. Initial and 24 hour disinfectant residuals in treated water in ppm for each outlet tested.
6. Date and time of flushing start and completion.
7. Disinfectant residual after flushing in ppm for each outlet tested.

C. Bacteriological Report:

1. Date issued, project name, and testing laboratory name, address, and telephone number.
2. Time and date of water sample collection.
3. Name of person collecting samples.
4. Test locations.
5. Initial and 24 hour disinfectant residuals in ppm for each outlet tested.
6. Coliform bacteria test results for each outlet tested.
7. Certify water conforms, or fails to conform, to bacterial standards of authority having jurisdiction.

D. Water Quality Certificate: Certify water conforms to quality standards of authority having jurisdiction, suitable for human consumption.

1.6 QUALITY ASSURANCE

A. Perform Work in accordance with AWWA C651.

1.7 QUALIFICATIONS

A. Testing Firm: Company specializing in testing potable water systems, certified by State of New Mexico.

B. Submit bacteriologist's signature and authority associated with testing.

PART 2 PRODUCTS

2.1 DISINFECTION CHEMICALS

A. Chemicals: AWWA B300, Hypochlorite, AWWA B301, Liquid Chlorine, AWWA B302, Ammonium Sulfate, and AWWA B303, Sodium Chlorite.

PART 3 EXECUTION

3.1 EXAMINATION

A. Section 01 00 00 - Administrative Requirements: Verification of existing conditions before starting work.

B. Verify piping system has been cleaned, inspected, and pressure tested.

C. Perform scheduling and disinfecting activity with start-up, water pressure testing, adjusting and balancing, demonstration procedures, including coordination with related systems.

3.2 INSTALLATION

A. Coordinate with Bureau of Reclamation, NTUA and the Engineer prior to filling, flushing or disinfecting the pipeline. Refer to Section 01 00 00 – Basic Requirements for coordination requirements.

B. Prior to disinfection, thoroughly flush the system with potable, disinfected water. A minimum flow velocity of 3 feet per second (fps) is required, or as otherwise approved by Engineer.

C. Provide and attach required equipment to perform the Work of this section.

D. Introduce treatment into piping system and perform disinfection in accordance with AWWA C651. A minimum chlorine concentration of 50 ppm shall be measurable throughout all parts of the system.

1. Measure chlorine concentration at all sampling ports provided on the Drawings, including air valve vaults and building plumbing.

E. Maintain disinfectant in system for 24 hours, or 48 hours if the temperature is less than 41 degrees Fahrenheit.

F. Flush, circulate, and clean using domestic water.

G. Neutralize residual chlorine to levels normally associated with potable water prior to discharging water to the environment.

H. Replace permanent system devices removed for disinfection.

3.3 FIELD QUALITY CONTROL

A. Section 01 00 00 - Execution Requirements: Field inspecting, testing, adjusting, and balancing.

B. Disinfection, Flushing, and Sampling:

1. Disinfect and test pipeline installation in accordance with AWWA C651.

2. Upon completion of retention period required for disinfection, flush pipeline until chlorine concentration in water leaving pipeline is no higher than that of the water used for flushing or 0.4 ppm, whichever is greater.
3. After final flushing and before pipeline is connected to existing system, or placed in service, employ an approved independent testing laboratory, approved by the Engineer, to sample, test and certify water quality suitable for human consumption, in accordance with AWWA C651.
   a. At least one set of bacteriological samples shall be collected from every 1,200 LF of new waterline, plus one set at each end of the line, unless otherwise approved by NTUA and the Engineer.
   b. Contractor shall install testing saddles, if needed to comply with spacing requirements for bacteriological testing under AWWA C-651 and NTUA's requirements. Such testing saddles are not shown on the plans, but shall be considered incidental to the project.
   c. The number and locations of specific sampling sites shall be submitted by the Contractor and must be approved by the Engineer prior to sampling.
   d. Bacteriological tests are typically only valid for 30 days. Two consecutive passing test results at every sample location must therefore be obtained within 30 days of Final Completion and Transfer of completed project to NTUA. Note that NTUA will not accept project transfer until all punch list items have been completed and the project has been inspected by NTUA personnel. NTUA typically requires 21 days notice prior to final inspection and Transfer. Contractor is solely responsible for coordination with NTUA. If punch list inspection, Final Completion, and NTUA Transfer cannot be completed within 30 days of all bacteriological tests, regardless of the reason for delay, Contractor shall be responsible for re-testing at Contractor's expense.
4. Contractor shall not connect to existing system until all testing and disinfection is complete and shall obtain written permission from the Engineer to proceed with connection to the existing system.

C. Re-Disinfection:

1. In the event the performed water quality testing fails, the Contractor will disinfect the affected portions of the system again, and the approved testing laboratory shall sample, test and certify water quality as described in these specifications. Re-disinfection shall be performed at no additional cost to the Owner.

END OF SECTION

SECTION 33 13 13

WATER STORAGE TANK DISINFECTION

PART 1 GENERAL

1.1 SUMMARY

A. Section Includes:

1. Water tank disinfection.

2. Bacteriological testing.

B. Related Sections:

1. Section 33 16 21 Glass Coated Bolted Steel Water Tanks

1.2 REFERENCES

A. American Water Works Association:

1. AWWA C652 - Disinfection of Water Storage Facilities.

1.3 MEASUREMENT AND BASIS OF PAYMENT

A. Basis of Measurement: Lump sum for each tank.

B. Basis of Payment: Via separate bid item on the Bid Form. Bid item price shall include all work performed by Contractor and testing laboratory related to disinfection, testing and analysis.

C. The cost of laboratory testing for bacteriological testing shall not be allowed under the Testing Allowance.

1.4 SUBMITTALS

A. Section 01 00 00 - Submittal procedures.

B. Disinfection Procedure: Submit procedure description including type of disinfectant to and calculations indicating quantities of disinfectants required to produce specified chlorine concentration in accordance with Section 3 and 4 of AWWA C652.

C. Test Reports: Indicate results of bacteriological and residual chlorine laboratory test reports.

D. Manufacturer's Certificate:

1. Certify products meet or exceed specified requirements.

2. Certify disinfectants meet or exceed AWWA Standards requirements.

1.5 QUALITY ASSURANCE

A. Perform Work in accordance with AWWA C652.

B. Perform Work in accordance with State of New Mexico Environment Department standards.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Store disinfectants in cool, dry place away from combustibles such as wood, rags, oils and grease.

B. Handle disinfectants with caution; protect skin and eyes from contact; avoid breathing vapors; wear gloves, aprons, goggles, and vapor masks.

1.7 ENVIRONMENTAL REQUIREMENTS

A. Furnish personnel working inside tank during disinfection with equipment to comply with Federal and State regulations for work conducted in hazardous atmosphere.

B. Neutralize disinfectant solution before disposal.

C. Legally dispose of disinfection solution off Project site.

D. Repair damage caused by disinfectant solution and disinfection procedures.

PART 2 PRODUCTS

2.1 DISINFECTANTS

A. Chlorine Forms: In accordance with AWWA C652, Section 4.2.

PART 3 EXECUTION

3.1 EXAMINATION

A. Conduct inspection of tank interior before beginning disinfection.

1. Verify tank is clean and free of polluting materials.
2. Verify tank pipe and vent connections are properly made and clear of obstructions.
3. Verify paint is thoroughly cured in accordance with paint manufacturer's instructions.

3.2 PREPARATION

A. Protect aquatic life and vegetation from damage from disinfectant solution purged from tank.

3.3 APPLICATION

A. Use Chlorination Method 2 for disinfecting tank as specified in Section 4.3 of AWWA C652.

3.4 FIELD QUALITY CONTROL

A. Section 01 00 00 - Testing, adjusting and balancing requirements.

B. Collect samples of water from filled tank for bacteriological analysis in accordance with Section 5.1 of AWWA C652; take inlet and outlet water samples.

C. Test water samples for bacterial contamination, residual chlorine, in accordance with State Health Standards for potable water.

D. When water samples fail to meet State Health Standards for potable water perform the following corrective measures until water quality conforms to State Health Standards:

1. Inlet and Outlet Water Sample Failure: Eliminate source of contamination in water supply, repeat disinfection, and retest water quality.

2. Outlet Water Sample Failure: Repeat disinfection, and retest water quality.

END OF SECTION

SECTION 33 16 21

GLASS COATED BOLTED STEEL WATER TANK

PART 1 GENERAL

1.1 SUMMARY

A. The work covered by this section of the specifications consists of furnishing all plant, labor, equipment and materials in performing all operations in connection with the manufacture, delivery and erection of factory glass coated bolted steel water storage tanks to the height and capacity specified, complete with foundation design and construction, and appurtenances, subject to the terms and conditions of the contract, and in strict accordance with this section of the specifications and the applicable drawings.

B. Section Includes:

1. Glass coated bolted steel water storage tank.
2. Tank foundation.
3. Tank coating.
4. Cathodic protection.
5. Tank disinfection.

C. Related Sections:

1. Information Available to Bidders: Exhibit A – Subsurface (Geotechnical) Investigation Report.
2. Section 03 30 00 - Cast-in-Place Concrete: Concrete materials.
3. Section 31 10 00 - Site Clearing
4. Section 31 22 13 - Rough Grading.
5. Section 31 23 17 - Trenching.
6. Section 31 23 23 – Backfill.
7. Section 33 11 13 - Public Water Transmission Systems.

1.2 REFERENCES

A. American Concrete Institute:

1. ACI 318 - Building Code Requirements for Structural Concrete.

B. ASTM International:

1. ASTM A53/A53M - Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless.
2. ASTM A615/A615M - Standard Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.
3. ASTM A570 - Mild Strength Steel

4. ASTM A607 - High Strength Steel
5. ASTM A36 or AISI 1010 - Rolled structural shapes.

C. American Water Works Association:

1. ANSI/AWWA D103 Section 12.4 & Section 10 of ISO 28765:2011 (latest version) - Factory-Coated Bolted Steel Tanks for Water Storage.
2. ANSI/AWWA D103 (latest version), Section 10.4 - Tank Coating System.
3. AWWA C652 - Disinfection

1.3 SYSTEM DESCRIPTION

A. Design, Furnish and erect one 500,000 gallon glass-coated, bolted-steel water storage tank, including foundation, tank structure, tank appurtenances, and cathodic protection system as described herein, complete in place. Stated volume of tank is nominal actual tank volume shall be within 2% of listed nominal volume.

1.4 DESIGN REQUIREMENTS

A. Roof: Non-corrugated domed aluminum roof

B. Location of Site: As indicated on Drawings.

C. Nearest Town: Community of Huerfano, San Juan County, New Mexico.

D. Access Roads: As indicated on Drawings.

E. Snow Loading: AWWA D103, (minimum 35 psf).

F. Wind Velocity 100 mph (AWWA D103 Std. is 100 mph).

G. Seismic Design:

1. AWWA D103, (Seismic Use Group III)
2. The Contractor shall be required to include minimum slosh wave calculations as part of his or her PE-sealed design submittals, and size the height of the tank accordingly.

H. Tank low level is defined as level when emptied through specified discharge fittings unless otherwise indicated on Drawings.

I. Floor Elevation: Finished floor elevation per Drawings.

J. The tank coating system shall conform solely to Section 10.4 of ANSI/AWWA D103, latest revision.

K. The tank system furnished by the tank manufacturer, which are in contact with the stored water shall be certified and listed by the NSF to meet ANSI/NSF Additives Standard No. 61. Certification of a coating type alone will not be sufficient to meet this requirement.

L. Cathodic protection to be passive anodes type, as specified herein.

M. Design and construct foundation based upon data and recommendations provided in Subsurface (Geotechnical) Investigation Report.

1.5 SUBMITTALS

A. Section 01 00 00 - Submittal Procedures: Requirements for submittals.

B. **Any submittal that does not meet all the requirements set forth below for content, clarity, specificity, and organization shall be rejected. Engineer reserves the right to back charge the tank supplier for excessive corrections and/or review time required due to failure of the supplier to provide adequate submittals and/or meet project specifications.**

C. All required parts of the tank submittal indicated in this section shall be submitted in a single complete bound package. Each separate part of the package shall be sectionalized and tabbed. The package shall include a table of contents.

D. Construction shall be governed by the Owner's drawings and specifications showing general dimensions and construction details, after written approval by the Engineer of detailed erection drawings prepared by the tank bidder. There shall be no deviation from the drawings and specifications, except upon written order from the Engineer.

E. Shop Drawings: Signed and sealed by professional engineer licensed in the State of New Mexico. All shop drawing shall be clear and legible, with all details and components clearly called-out. Materials of construction shall be clearly identified. All relevant dimensions shall be labeled. Indicate the following:

1. Tank Shop Drawings:

    1. Include dimensions, tolerances, material data, joint details, welding requirements, painting, lining, and coating requirements within the construction phase.

    2. Complete plan, elevation, and sectional drawings showing critical dimensions.

    3. Tank shell and roof design calculations per Manufacturer’s standard format.

    4. Structural plate and support member sizes and thickness.

    5. Bolt plan. Water supply and overflow piping details including fittings, expansion joints, and pipe support methods.

    6. Exterior ladder safety device details.

    7. Handrail details.

    8. Access hatch details.

    9. Level indicator details.

    10. Vent details.

    11. Floor plan including all pipe penetrations and panel bolt lines.

    12. Other appurtenances as indicated on plans or as provided by manufacturer.

    13. Cathodic protection details.

2. Tank Foundation Shop Drawings:
   1. Submit specification for foundation describing all material to be used, configuration, compaction requirements, etc. prepared by professional engineer licensed in the State of New Mexico.
   2. If proposed foundation is constructed of concrete, indicate the following:
      1) Ingredients, reinforcement, air content, slump, placement and consolidation, curing and finishing.
      2) Submit concrete design mix including ingredient proportions, minimum cement content, and water/cement ratio.
      3) Submit drawings of reinforcing bars including bar lists.

F. Product Data:
   1. Submit data for expansion joint fittings and other pipe specialty fittings.
   2. Submit data for ladders and ladder safety devices.
   3. Submit data for cathodic protection components.

G. Design Data: Submit structural calculations for tank, tank foundation, and cathodic protection, signed and sealed by professional engineer licensed in the State of New Mexico.

H. Manufacturer’s instructions for erection of tank, including details on bolting, placement of gaskets and/or sealants, coating repair procedures, assembly procedures within the construction phase.

I. Color Sample: Submit color sample.

J. Test Reports: Submit test reports for all factory and field performed quality assurance tests.

K. Manufacturer's Certificate: Certify products meet or exceed specified requirements.

L. Manufacturer's Field Reports: Certify foundation, anchor bolts, and tank have been properly installed and leveled.

M. The intent of these specifications is to provide the Owner with a water storage tank of the dimensions stated, requiring minimum maintenance. Alternative submittals will be accepted, provided the installation offered can be shown to be “equal” to the specified standard of quality, beyond reasonable doubt.

N. The tank manufacturer's standard published warranty shall be included with submittal information.

1.6 CLOSEOUT SUBMITTALS

A. Section 01 00 00 - Execution Requirements: Requirements for submittals.

B. Project Record Documents: Record actual location layout and final configuration of tank and accessories.

C. The tank manufacturer shall include a standard Operation and Maintenance Manual upon receipt of approved drawings.

1.7 QUALIFICATIONS

A. Fabricator: Company specializing in performing work of this section with minimum five years experience.

B. Installer: Company specializing in performing work of this section with minimum five years experience in the State of New Mexico, approved by Engineer.

C. The Engineer's selection of factory applied glass-fused-to-steel bolt together tank construction for this facility has been predicated upon specific criteria, construction methods, and an optimum coating for resistance to internal and external tank corrosion. Deviations from the specified design, construction or coating details, will not be permitted.

D. Strict adherence to the standards of design; fabrication; erection; product quality; and long-term performance, established in this Specification will be required by the Owner and Engineer.

E. Design ground supported water tank and foundations under direct supervision of Professional Engineer experienced in design of this Work and licensed in the State of New Mexico.

F. Manufacturers shall provide a list of 10 tanks located within the State of New Mexico and/or the Navajo Nation to demonstrate their experience, complete with owners contact information and phone number. The Owner's decision of judgment on these matters will be final, conclusive and binding.

G. The tank manufacturers glass coating product shall be independently audited on an annual basis to confirm compliance to ISO 28765:2011

1.8 PRE-INSTALLATION MEETINGS

A. Section 01 00 00 - Pre-Construction Conference.

B. Convene minimum one week prior to commencing work of this section.

1.9 FIELD MEASUREMENTS

A. Verify field measurements prior to fabrication.

B. Prior to submittal of tank manufacturer's Shop Drawings, Contractor shall independently field survey overflow weir elevations of existing DZ Regulating tank.

1. Overflow weir elevation of new Reach 21 Tank No. 3 shall match that of the existing ENWP Phase 3 - 30 ft. tall DZ Regulating tank within a tolerance of ½".

1.10 COORDINATION

A. Section 01 00 00 - Basic Requirements: Coordination requirements.

B. Coordinate work with connecting to water distribution system.

1.11 MAINTENANCE MATERIALS

A. Section 01 00 00 - Basic Requirements: Operation and maintenance data requirements.

B. Furnish two safety harnesses for ladder safety rail system.

PART 2 PRODUCTS

2.1 MANUFACTURERS:

A. Permastore Ltd

B. Substitutions: Approved Equal

2.2 PLATES AND SHEETS

A. All steel shall be smelted and produced in the United States of America.

B. Plates and sheets used in the construction of the tank shell, tank floor (when supplied) and tank roof, shall comply with the minimum standards of AWWA D103, latest edition.

C. Design requirements for mild strength steel shall be ASTM A1011 Grade 30 with a maximum allowable tensile stress of 14,566 psi.

D. Design requirements for high strength steel shall be ASTM A1011 Grade 50 with a maximum allowable tensile stress of 26,000 psi.

E. The annealing effect created from the glass coated firing process shall be considered in determining ultimate steel strength. In no event shall a yield strength greater than 50,000 psi be utilized for calculations detailed in AWWA D103, latest edition, Sections 3.4 and 3.5.

F. When multiple vertical bolt line sheets and plates of ASTM A1011 Grade 50 are used, the effective net section area shall not be taken as greater than 85% of the gross area.

2.3 ROLLED STRUCTURAL SHAPES

A. Material shall conform to minimum standards of ASTM A36, ASTM A992, or AISI 1010.

2.4 HORIZONTAL WIND STIFFENERS

A. Design requirements for intermediate horizontal wind stiffeners shall be of the "web truss" design with extended tail to create multiple layers of stiffener, permitting wind loads to distribute around tank.

B. Web truss stiffeners shall be of steel with hot dipped galvanized coating.

C. Rolled steel angle stiffeners are not permitted for intermediate stiffeners.

2.5 BOLT FASTENERS

A. Bolts used in tank lap joints shall meet the minimum requirements of AWWA D103, Section 2.2.

B. All bolts shall be fully threaded into nuts.

C. Bolt Material

1. Bolts used in tank lap joints:
   1. Shall be ½" – 13 UNC-2A rolled thread, conforming to ASTM A325 and A490.

2. ASTM A325 Compliant Bolts:
   1. Minimum Tensile Strength – 120,000 psi
   2. Minimum Proof Load – 85,000 psi
   3. Minimum Allowable Shear Stress with threads excluded from the shear plane – 30,000 psi

3. ASTM A490 Compliant Bolts:
   1. Minimum Tensile Strength – 150,000 psi
   2. Minimum Proof Load – 120,000 psi
   3. Minimum Allowable Shear Stress with threads excluded from the shear plane –37,500 psi

D. Bolt Finish – Galvanized per AWWA D-103

1. 2.0 Mils Min - under bolt head, on shank and threads.

2. Plastic bolt caps shall be installed on the exterior of the tank.

3. Color to match the finished tank color.

E. Bolt Head Encapsulation

1. High impact polypropylene copolymer encapsulation of entire bolt head up to the splines on the shank.

2. Resin shall be stabilized with an ultraviolet light resistant material such that the color will be coded based on manufacturer's standard.

3. The bolt head encapsulation shall be certified to meet the ANSI/NSF Standard 61 for indirect additives.

F. All bolts on the vertical tank wall shall be installed such that the head portion is located inside the tank, and the washer and nut are on the exterior.

G. All lap joint bolts shall be properly selected such that threaded portions will not be exposed to the "shear plane" between tank sheets.

H. Bolt lengths shall be sized as to achieve a neat and uniform appearance. Excessive threads extending beyond the nut after torquing will not be permitted.

I. All lap joint bolts shall include a minimum of four (4) splines on the underside of the bolt head at the shank in order to resist rotation during torquing.

J. Caps to be installed on heads of all bolts.

2.6 SEALANTS

A. The lap joint sealant shall be a one component, moisture cured, polyurethane compound **(Sika TS Plus)**. The sealant shall be suitable for contact with potable water and shall be certified to meet the NSF/ANSI Standard 61 for indirect additives.

B. The sealant shall be used to seal lap joints, sheet edges and bolt connections for sheet notches and starter sheets. The sealant shall cure to a rubber-like consistency, have excellent adhesion to the glass coating, low shrinkage, and be suitable for interior and exterior use.

C. Sealant curing rate at 73 degrees F and 50% RH

1. Tack-free time: 6 - 8 hours

2. Final cure time: 10 to 12 days

D. The sealant shall be approved by the Engineer as part of Contractor's Submittals.

E. Neoprene gaskets and tape type sealer shall not be used.

2.7 PIPE PENTRATIONS

A. Pipe penetrations

1. Do not penetrate tank floor along panel seams.
   1. A minimum of 3" clearance is required from the OD of pipe connect flange to the seam.

2. Coordinate with Engineer to adjust tank floor layout plan and/or pipe penetration locations to ensure pipe collar does not interfere with panel seams.

3. All penetrating pipes and pipe collars shall be 304 stainless steel or fusion-bonded epoxy (FBE) coated, both interior and exterior. Refer to Section 33 11 13 – Public Water Transmission Systems for FBE specifications.
   1. Galvanized steel penetrating pipes and pipe collars shall not be accepted.

4. All exterior surfaces of all buried non-stainless metallic pipe, pipe collars, and welded fittings shall include cold-applied tape coating, manufactured and installed in accordance with AWWA C209, applied with a minimum overlap width of 1-inch and a total coating thickness shall be a minimum of 80 mils. Such tape coating shall be applied in addition to FBE coatings cited above.

5. Link seals shall have all 304 stainless steel hardware.

PART 3 EXECUTION

3.1 EXAMINATION

A. Section 01 00 00 - Administrative Requirements: Verification of existing conditions before starting work.

B. Verify elevations and grading for tank and location of tank.

C. Refer to Section 31 22 13 for excavation and Section 31 23 23 for backfill requirements.

3.2 GLASS COATING SPECIFICATION

A. Surface Preparation

1. Sheets shall be steel grit-blasted to a silver-grey finish on both sides to remove mill scale and surface oxidation.

2. Grit blasting shall be performed to the equivalent of SSPC SP10/NACE No 2, as required by AWWA D103-09.

3. The surface anchor pattern shall be in the range of 1.0 mil to 4.0 mils, with a target value of 2.4 mils.

B. Cleaning

1. After fabrication and prior to application of the coating system, all sheets shall be thoroughly cleaned by a caustic wash and hot rinse process followed immediately by hot air drying.

2. Inspection of the sheets shall be made for traces of foreign matter or rust. Any such sheets shall be recleaned or grit-blasted to an acceptable level of quality.

C. Fabrication

1. The sheets shall be fabricated prior to coating, trimming to the proper length and width, and putting all bolt seam holes and manways in place.

2. The sheets shall be rolled to the finished tank diameter prior to coating. Field bending of the sheets to the tank diameter will not be permitted.

D. Coating

1. All sheets shall receive a pre-coat to both sides. The pre-coat application weight is controlled and measured and sheets that do not meet the required specification, in accordance with the Manufacturer's specified parameters, shall be rejected at this point.

2. All pre-coated sheets shall be heat dried to ensure that a moisture free surface has been achieved before the glass coating layer is applied.

3. A coat of cobalt rich glass slip shall be continuously applied to both sides of the sheet followed by heat drying.

4. The coated sheets shall be visually inspected and sheets with spray or glass defects shall be rejected at this point.

5. The thickness of the coating system shall be measured using an electronic instrument; the instrument shall have a valid calibration record. Interior and exterior dry film coating thicknesses are controlled and measured and sheets that do not meet the required specification, in accordance with the Manufacturer's specified parameters, shall be rejected at this point.

6. After inspection the sheets shall be fired through the furnace at approximately 1500°F in accordance with the Manufacturer's procedures.

7. A second coat of cobalt rich glass slip shall be continuously applied to both sides of the sheets. The internal glass is a dedicated high-performance material and delivers exceptional resistance to chemical corrosion.

8. Stages D.4 to D.6 are repeated.

9. The firing processes shall form a composite glass surface having general acid/alkali resistance to solutions in the range pH 2 to pH 11 subject to temperature and chemical composition.

10. Tank internal sheet color shall be white. Standard tank external color shall be Forest Green (12-B-29). An additional range of optional or special external colors are available by agreement with the Manufacturer.

11. Sample tests shall be carried out in accordance with ISO 28765 section 10 by the Manufacturer to ensure that enamel materials meet the physical properties and chemical resistance characteristics specified as published in the Manufacturer's product Quality Standard. The Manufacturer shall provide published product Quality Standards detailing the International Standards used for testing.

12. The tank manufacturers glass coating product shall be independently audited on an annual basis to confirm compliance to ISO 28765:2011

13. The sheet edges shall receive an electrostatically applied pre-coat to achieve a durable glass coating. A further factory applied coating of a quick drying, single component stabilizing finish, reinforced with flat self-leafing glass flake, is applied to the sheet edges after firing and before packing. This material provides additional protection to the edges during transit, site storage and installation.

14. Correct joint design methodology shall be used to uniformly distribute the load over a sufficient surface area to maximize bond strength. Full sealant over pointing from the sheet edge and extending onto the next ring of sheets shall be used to ensure the tank fluid pressure maintains a low stress sealant joint and protects the sheet edges from liquid and mechanical hazards.

15. Full protection and sealing of the sheet edges and tank overlap shall be achieved by the application of polyurethane sealant specifically designed for use with glass-fused-to-steel tanks. (Refer to Section 3.0 paragraph E)

16. The thickness of the glass on the inside surface of every sheet shall be maintained in the range from 11.0-18.1 mils.

17. The thickness of the glass on the outside surface of every sheet shall be maintained in the range from 9.8-19.7 mils.

E. Factory Inspection

1. The manufacture's quality system shall be ISO 9001 certified and refer to ISO (International Organization for Standardization) for the following testing and procedures:

2. Visual Inspection
    1. The outside surface of all sheets shall be inspected visually under good daylight (or equivalent lighting) for defects in the glass coating.
    2. Any sheet having visible defects larger than 0.039” shall be rejected. Any sheet having more than three visible defects per square yard of the total sheet area shall be rejected.
    3. Any visible defects on the outside surface of accepted sheets shall be repaired using a repair material approved by the Manufacturer for this purpose and applied according to the repair material Manufacturer’s instructions.

3. Chemical Resistance of Glass Coating

   1. Frits shall be individually tested in accordance with pertinent sections of ISO 28706-1:2008.

4. Factory Holiday Test

   1. Holliday testing per AWWA D103 is required. The maximum voltage of the meter shall not exceed 67.5 volts for wet testing. For dry testing a minimum of 1100 volts is required.

   2. Frequency of the test shall be every sheet. Any sheet registering a discontinuity shall be rejected. No factory touch ups or repairs shall be permitted.

5. Measurement of Glass Thickness

   1. Glass thickness shall be measured using an electronic dry film thickness gage (magnetic induction type). The thickness gage shall have a valid calibration record.
   2. The thickness of the glass on the inside surface of every sheet shall be maintained in the range from 11.0-18.1 mils.
   3. The thickness of the glass on the outside surface of every sheet shall be maintained in the range from 9.8-19.7 mils.

6. Measurement of Color

   1. The exterior color of the sheets shall be checked for color uniformity.

7. Impact Adherence Test

   1. The adherence of the glass coating to the steel shall be tested in accordance with ISO standards. Any sheet that has poor adherence shall be rejected.

8. Fish scale Test

   1. The glass coating shall be tested in-house for fish scale by placing the full-size production sheets in an oven at 400º F for one hour. The sheets will then be examined for signs of fish scale. Any sheet exhibiting fish scale shall be rejected and all sheets from that gage lot will be similarly tested.

F. Packaging

1. All sheets that pass Factory Inspection and Quality Control Checks shall be protected from damage prior to packing for shipment.

2. Heavy paper or plastic foam sheets shall be placed between each panel to eliminate sheet-to-sheet abrasion during shipment.

3. Individual stacks of panels will be wrapped in heavy mil black plastic and steel banded to special wood pallets built to the roll-radius of the tank panels. This procedure eliminates contact or movement of finished panels during shipment.

4. Shipment from the factory will be by truck, hauling the tank components exclusively.

3.3 FOUNDATION

A. A site-specific foundation design stamped by a Licensed Professional Engineer in the state of New Mexico based on the soils report shall be submitted.

B. The tank foundation shall be designed by the manufacturer to safely sustain the structure and its live loads. Tank foundation shall be concrete ringwall or concrete mat type foundation.

C. The tank foundation shall be either a concrete ringwall or concrete mat.

D. Tank footing design shall be based upon data and recommendations provided in Subsurface (Geotechnical) Investigation Report. A copy of the report is included in the appendices to the construction documents.

E. Footing designs for soil bearing strengths less than that specified, and those designs deviating from tank manufacturers standard shall be the responsibility of the Owner and his Engineer based on tank live and dead loading data provided by the tank manufacturer.

F. Anchor bolts shall be fusion boded epoxy coated. After anchor bolts have been installed, any fusion bonded epoxy that has been removed during installation shall be field touched up with two-part epoxy meeting requirements of AWWA C210 and technical specification 33 11 13.

3.4 TANK FLOOR

A. Tank floor and foundation shall be designed by a Professional Engineer licensed in the State of New Mexico. Tank manufacturer shall submit complete design calculations and drawings bearing PE seal prior to fabrication or installation. Floor shall consist of one of the types specified below, at Contractor’s option.

1. Concrete Floor

   1. The standard floor design is of reinforced concrete with an embedded glass coated steel starter sheet per the manufacturer's design and in accordance with AWWA D103, latest edition, sec 8.11.4. Slot Mount style foundation is not acceptable.

   2. Leveling of the starter ring shall be required and the maximum differential elevation within the ring shall not exceed one-eighth (1/8) inch, nor exceed one-sixteenth (1/16) inch within any ten (10) feet of length.

   3. A leveling plate assembly (U. S. Patent No. 4,483,607), consisting of two 18" anchor rods (3/4" dia.) and a slotted plate (3 1/2" x 11" x 3/8" thick) shall be used to secure the starter ring, prior to encasement in concrete. Installation of the starter ring on concrete blocks or bricks, using shims for adjustment, is not permitted.

   4. Place one butyl rubber elastomer waterstop seal on the inside surface of the starter ring below concrete floor line. Place one bentonite impregnated water seal below the butyl rubber seal. Install materials in accordance with tank manufacturer's instructions.

5. A leveling plate assembly consisting of two anchor rods and a slotted plate shall be used to secure the starter ring, prior to encasement in concrete. Installation of the starter ring on concrete blocks or bricks, using shims for adjustment, is not permitted.

2. Glass Coated Bolted Steel Floor

1. Bolted steel panels shall be either placed over a 3 inch (76 mm) compacted sand base contained by a steel or concrete ring wall, or a non-extruding and resilient bituminous type filler meeting the requirements of ASTM D1751 if set on a concrete slab.

2. A plastic encapsulated nut shall be used to cover the bolt threads exposed on the inside of the floor. The plastic encapsulation shall be NSF compliant.

3. Leveling of the starter ring shall be required and the maximum differential elevation within the ring shall not exceed 1/8 inch (3 mm), nor exceed 1/16 inch (2 mm) within any 10 feet (3048 mm) of length.

3.5 SIDEWALL STRUCTURE

A. Field erection of the glass-coated, bolted-steel tank shall be in strict accordance with the procedures outlined in the manufacturer's erection manual, and performed by an authorized dealer of the tank manufacturer, regularly engaged in erection of these tanks, using factory trained and certified erectors.

B. Specialized erection jacks and building equipment developed and manufactured by the tank manufacturer shall be used to erect the tank.

C. Particular care shall be taken in handling and bolting of the tank panels and members to avoid abrasion of the coating system. Prior to a liquid test, all surface areas shall be visually inspected by the Engineer.

D. An electrical leak test shall be performed during erection using a wet sponge nine (9) volt leak detection device. Any electrical leak points found on the inside surface shall be repaired in accordance with manufacturer's published touch up procedure.

E. The placement of sealant on each panel may be inspected prior to placement of adjacent panels. However, the Engineer's inspection shall not relieve the bidder from his responsibility for liquid tightness.

F. No backfill shall be placed against the tank sidewall without prior written approval and design review of the tank manufacturer. Any backfill shall be placed according to the strict instructions of the tank manufacturer.

3.6 ROOF

A. Geodesic Dome Roof

1. The roof shall be constructed of non-corrugated triangular aluminum panels which are sealed and firmly clamped in an interlocking manner to a fully triangulated aluminum space truss system of wide flange extrusions, thus forming a dome structure.

2. The roof shall be a dome structure conforming to AWWA Standard D108-10 “Aluminum Dome Roofs for Water Storage Facilities”. The dome shall conform to the dimensions of the tank using a fully triangulated space truss and non-corrugated closure panels. It shall be clear-span and designed to be self-supporting from the periphery structure with primary horizontal thrust contained by an integral tension ring. Provision shall be made in the design for thermal expansion of all dome parts over a temperature range of -40°F to +140°F.

3. The dome surface paneling shall be designed as a watertight system under all design load and temperature conditions. All raw edges of the aluminum panels shall be covered, sealed, and firmly clamped with batten bars in an interlocking manner to prevent slipping or disengagement under design load and temperature changes.

4. The roof framing system shall be designed as a three dimensional truss with moment-resisting joints. The design must consider the increased minor axis bending and compression induced in the framing members due to tension in the roof panels.

5. The dome and tank shall be designed to act as an integral unit. The tank shall be designed to support an aluminum dome roof including all specified live loads.

    1. The structural analysis shall be performed using stiffness analysis models. The structural computer models shall include the effect of geometry irregularities such as dormer openings and perimeter support members.

    2. Connection forces shall be transferred through gusset plates connected to the top and bottom flanges of the beam-struts. The connections shall be designed as moment connections; a minimum of four bolts shall be used to connect the gusset plate to each strut flange.

    3. The design of welded components shall be in accordance with the Aluminum Structural Welding Code ANSI/AWS D1.1/D1.2.

    4. The vertical loads transferred from the roof to the tank shall be in-line with the tank wall. The transfer of horizontal loads to the tank shall be minimized by means of low friction slide supports. Radial forces applied to the tank shall not exceed 10% of the vertical reactions.

    5. Dissimilar materials which are not compatible shall be isolated by an insulator to prevent galvanic corrosion.

B. Geodesic Dome Materials:

1. Triangulated dome frame struts: 6082/T6 aluminum

2. Structural frame gussets: 0.393” minimum thickness 6082/T651 aluminum.

3. Triangular closure panels: 0.048” minimum thickness 3003-H16 aluminum sheet.

4. Triangular Skylight panels, (if specified): 0.236” thick clear acrylic. Skylight square footage shall be 1% of covered area, minimum.

5. Clamping bars must have M8-bolts CNC-drilled holes to ensure a 360° bolt grip for greater clamping force.
6. Perimeter tension/compression ring: 6082/T6 aluminum.
7. Fasteners: Stainless Steel 316L/Grade 80 for bolts and nuts.
8. Sealant: Silicone, conforming to Federal Specification TT-S-00230 as manufactured by Pecora, #864, or equal.
9. Gaskets: Silicone, conforming to Federal Specification ZZ-R-765, class 2, grade SO as manufactured by General Electric, #SE-44/88, or Neoprene equal.
10. Silicone free hubcaps to allow quick and precise installation.
11. Anchor Bolts: Stainless Steel 316L/Grade 80.
12. Dormers, doors, vents and hatches: 5754 aluminum, 0.078”-0.118”1 nominal thickness.

C. Roof Vent

1. A properly sized vent assembly in accordance with AWWA D103-09 shall be furnished and installed above the maximum water level of sufficient capacity so that at maximum design rate of water fill or withdrawal, the resulting interior pressure or vacuum will not exceed 0.5" water column.
2. Mushroom vent above maximum water level of sufficient size to accommodate the following flow rate:
    1. 8.4 cfs (3,743 gpm) at high water level
3. Vent shall comply with EPA Region 8 Drinking Water Unit Tech Tips for the Sanitary Protection of Drinking Water Storage Tanks.
4. The overflow pipe shall not be considered a tank vent. Provide aluminum, fiberglass, or bronze insect screen, 24-mesh. Vent shall be frost proof.
5. The vent shall be constructed of aluminum such that the hood can be unbolted and used as a secondary roof access.

3.7 APPURTENANCES (PER AWWA D103, SECTION 5)

A. Pipe Connections

1. Provide inlet pipe with diameter as indicated on Drawings. Extend pipe through bottom of tank to height indicated on construction drawings.
2. Provide schedule 40 steel piping overflow pipe coated interior and exterior with fusion bonded epoxy in accordance with AWWA C213. All ells shall be welded to pipe prior to coating.
3. Connections shall be shall be field located, saw cut, (acetylene torch cutting or welding is not permitted), and utilize an interior and exterior flange assembly and the tank shell reinforcing shall comply with AWWA D103, latest edition. Sika TS PLUS Sealant shall be applied on any cut panel edges or bolt connections.
4. Provide other accessories as indicated on Drawings.

B. Removable Silt Stop: AWWA D103, provide removable FBE coated steel silt stop and MJ gland.

C. Overflows

1. Overflow: AWWA D103. Provide schedule 40 steel piping overflow pipe coated interior and exterior with fusion bonded epoxy in accordance with AWWA C213 as indicated on Drawings suitably supported and extending to grade level; diameter of overflow as indicated on Drawings. Each segments of overflow including ells, fittings, and connection between pipe and weir box shall be welded prior to coating. Provide overflow weir box designed to handle flow as follows:

    1. 8.4 cfs (3,743 gpm) at high water level

D. Tank Ladders

1. An outside tank ladder shall be furnished and installed as shown on the contract Drawings.
2. Outside ladder shall be fabricated of aluminum and utilize grooved, skid-resistant rungs.
3. Safety cage and step-off platforms shall be fabricated of galvanized steel. Ladders shall be equipped with a hinged lockable entry device. Must include fall protection from 8' off the ground and above.
4. Safety cage shall include steel mesh with 0.33 sq. inch openings covering the bottom 8 ft of the safety cage.
5. Designed to meet OSHA Standards, and AWWA D103.
6. Ladder must extend to 2' off the ground.
7. Safety climb to be provided.
8. Handrail each side of ladder.

E. Access Doors

1. Access doors shall be provided as shown on the Drawings in accordance with AWWA D103, latest edition.
2. The manhole openings shall be of the dimensions indicated on the Drawings. The access doors (shell manholes) and the tank shell reinforcing shall comply with AWWA D103, latest edition, Sec. 5.1.

F. Balcony: AWWA D103

G. Safety Cages, Rest Platforms, Roof-Ladder Handrails or Other Safety Devices: AWWA D103.

1. Safety Devices: Provide safety cable, complying with OSHA Standards, along entire ladder length.

2. Provide anchor points for operator to connect lanyards, “pelicans” or similar personal safety devices, complying with OSHA standards, at three points along roof of tank: near top of ladder, between center of tank and roof hatch, and near center of tank.

3. Ladder shall be secured with a side opening security door.

H. Hatch: Provide tank roof hatch with curbed, upward opening 30” square manway. The curb shall extend at least 4 inches above the tank. The hatch cover lip shall be hinged and provisions made for locking. The hatch cover lip should extend for a distance of 2 inches down on the outside of the curb.

I. Identification Plate: A manufacturer's nameplate shall list the tank serial number, tank diameter and height, and maximum design capacity. The nameplate shall be affixed to the tank exterior sidewall at a location approximately five (5) feet from grade elevation in a position of unobstructed view.

J. Water Level Indicator: A water level indicator shall be furnished including target, cable, floats, channel, guides, etc., as required for complete assembly.

K. Targets: Target cables shall be provided with guides to prevent cables from tangling with target.

L. Dome Access: Provide handrails with non-skid tape and safety cable to dome apex.

M. Cathodic Protection

1. The tank shall be supplied with a magnesium anode, passive cathodic protection system designed by supplier’s certified by a NACE Cathodic Protection Specialist, certified and/or licensed at location of project. Design of the anode system shall be based on the resistivity of the water to be stored in the tank. The tank supplier will test the conductivity of the water prior to designing the cathodic protection system.

2. Electrical continuity between all tank sidewall panels shall be the responsibility of the tank manufacturer.

3.8 FIELD TESTING

A. Hydrostatic

1. Following completion of erection and cleaning of the tank, the structure shall be tested for liquid tightness by filling tank to its overflow elevation for 24 hours.

2. Any leaks disclosed by this test shall be corrected by the erector in accordance with the manufacturer's recommendations.

3. Test completed and cleaned tank for liquid tightness by filling tank to its overflow elevation with water provided by Contractor.

4. Drain and legally dispose test water off site.

5. Labor and equipment necessary for tank testing is to be included in the price of the tank.

B. Concrete testing for foundation in accordance with Section 03 30 00, if applicable.

C. Holiday testing per AWWA D103 is required. The maximum voltage of the meter shall not exceed 67.5 volts for wet testing. For dry testing a minimum of 1100 volts is required.

1. Contractor Support: Contractor shall provide NACE inspector with safe access to tank fabrication facilities and all points within the tank interior and exterior requiring inspection, including all required safety rigging and safety equipment. Contractor and Engineer shall be present for all inspections by the NACE inspector.

D. Coating Damage

1. If there is more than 5 separate damages (chips, scraps, gouges, scratches, holidays) to the glass coating on any one sheet, the sheet will be rejected and replaced at the tank supplier’s expense.

2. If there is any more than 3 square inches of damage or holidays to the glass coating on any single sheet, the sheet will be rejected and replaced at the tank supplier’s expense.

3. Any sheets that are bent or deflected prior to construction or deflected during construction shall be rejected and replaced at the tank supplier’s expense.

3.9 CLEANING

A. Section 01 00 00 - Final cleaning requirements.

B. Clean interior and exterior of tank to remove debris, construction items, and equipment.

C. Disinfect tank in accordance with Section 33 13 13.

1. Disinfection shall not take place until tank sealant is fully cured (see article related to Sealants above).

2. Acceptable forms of chlorine for disinfection shall be:

   1. Liquid chlorine as specified in AWWA C652.

   2. Sodium Hypochlorite as specified in AWWA C652.

   3. Calcium Hypochlorite (HTH) in not acceptable.

3. Acceptable methods of chlorination per AWWA C652:

   1. Section 4.1.1.

   2. Section 4.1.2 - chemical feed pump only (4.1.2.1).

   3. Section 4.3

4. Section 4.2 is not acceptable.

3.10 TANK MANUFACTURER'S WARRANTY

A. Structure

1. The tank manufacturer shall warrant that the liquid storage tank and foundation will be free from defects in workmanship and materials, under normal and proper use, maintenance and operation, during the period expiring one year after the date

of final Affidavit of Punch List Completion by NTUA and acceptance from the Owner.

B. Additional Warranty

1. The tank manufacturer shall provide a written 10-year warranty against corrosion of the submerged tank interior surfaces. The warranty shall include repair or replacement of any tank sheet(s) which has (have) corroded within the initial 10-year (120 month) period, by the tank manufacturer.

2. Tank inspections shall be completed the first (1^{st}), third (3^{rd}), sixth (6^{th}), and ninth (9^{th}) year after installation by the tank installer at no cost to the Owner.

END OF SECTION

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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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

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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 **CHLORINE RESIDUAL ANALYZER AND TRANSMITTER**	**Cutter Lateral WTP** **AIT-900-100-01**

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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 **CHLORINE RESIDUAL ANALYZER AND TRANSMITTER**	**Cutter Lateral WTP** **AIT-900-100-02**

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